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PROJECT USE IN THE TEACHING

OF HIGH SCHOOL BIOLOGY

A Paper
Presented To the Faculty Of
Eastern Illinois University
Charleston, Illinois

Submitted in Partial Fulfillment
Of The Requirements For The Degree
Master of Science in Education

By

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Approved:

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Date: 3 August 1960

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PREFACE

Biology texts propose different methods of teaching biology including the use of projects. The method that is being presented in this Plan B paper is the teaching of biology with the use of projects.

This project method has been used very successfully in a biological science course at the LaGrove High School, Farina, Illinois, for the past eight years. The material in this paper was used in biology classes during the 1959-60 school year at the LaGrove High School. It is felt that the results indicate its success anywhere on the high school level.

The writer wishes to acknowledge the advice and assistance given to her during the preparation of this paper. I am especially indebted to Doctor Walter M. Scruggs for his inspiration, suggestions, and patience; to Doctor Gilbert W. Mouser for his support and encouragement; to Mr. Paul E. Bauer for his loyalty and photographic help; and to Mr. James L. Rhodes and Mrs. Prudie Hudson for technical assistance.

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CHAPTER I

THE USE OF PROJECTS IN HIGH SCHOOL BIOLOGY

There is more controversy about science teaching today. At the moment there is widespread concern about all education, but especially the secondary school curriculum is the focus of attention. One idea has emerged from the chaos, and it is that the "age of science" demands a program of education consistent with the times.

The standard American science curriculum often includes ninth-grade general science, tenth-grade biology, eleventh-grade chemistry, and twelfth-grade physics. Enrollments in these subjects, expressed as percentages of the appropriate grade groups, are as follows, on a national basis: "general science 67 percent, biology 75.5 percent, chemistry 34.6 percent, physics 24.3 percent."[1]

Burton E. Voss[2] made a survey in the Iowa high schools in 1957-58. The data was collected by a questionnaire returned by administrators and teachers, and by personal visitation to science classes and interviews with science teachers.

A study of this curriculum (in Voss' survey) showed that in 1934, 10.6 percent of the students in Iowa high schools were enrolled in biology, while in 1958, only 21.3 percent were enrolled. The percentage

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[1]William O. Stanley, Harry S. Brandy, and R. Will Burnett, Improving Science Programs in Illinois Schools (Urbana, Illinois: University of Illinois, 1958), p. 45.

[2]Burton E. Voss, "Biology - Fact and Future," The American Biology Teacher, Volume 22, No. 2 (February, 1960), pp. 79-82.

of Iowa high schools offering biology increased from 45.7 percent in 1934 to 82.2 percent in 1958. Further examination of the data revealed that 94.83 percent of the high schools offered biology because some of them offered it in alternate years.

About 77 percent of these Iowa schools placed biology in the tenth grade. Three percent offered biology to a combination of ninth and tenth grade students, and twenty percent offered it to combinations of tenth, eleventh, and twelfth grade students. Some school administrators were considering moving the tenth grade biology into the ninth grade because they felt their students were obtaining good science background in grades seven through eight. A reason given for keeping biology in the tenth grade was the lack of uniformity of experiences in the lower grades, thus suggesting that the general science course is needed in the ninth grade. The content of biology has changed very little over the last twenty-five years. An analysis of biology texts from the period of 1930 to 1957 revealed few changes. Major changes were in the field of medicine - the antibiotics, the Salk vaccine and atomic energy - as applied to biology. The large number of topics presented in 1930 had been condensed into fewer comprehensive units. The teachers stated they were attempting to meet the problems of individual differences by having students do projects, make extra reports, read scientific journals and magazines, or through the science club. About 35 percent of the teachers had students do biology projects. However, very few projects were observed in the biology classrooms.

How do we meet the challenge of our time? It is essential that one become an artist by drawing, a baker by baking, a teacher by teaching, a scientist by "sciencing," an actor by acting, and a doctor by doctoring.

The sooner he begins to draw or to bake or to do science or to teach or to doctor, the sooner he creates, the sooner he actually becomes an artist or baker or scientist or actor or doctor. A course in which the youngster has an opportunity to create fits our gifted, or science-prone. They are the students that are expected to become our "doers," our "creative minds," our inventors, and the originators in all areas. Certainly it is necessary for young people to study textbooks and to repeat experiments via the workbook and manual, for the knowledge gained is essential to the preparation of all cultured men. A course in "Great Experiments" or "Great Laws" or "Great Principles" (our present courses in science and mathematics) is just as valuable as a course in "Great Books." To create and originate, our boys and girls must have opportunity to work on their own level. This implies both time and motivation within an encouraging school atmosphere. These in turn imply a teaching method which recognizes pupils' strengths and abilities along with their weaknesses and lack of experience. It means constant labor, a scholar's attitude, and work.[3] One of the teaching methods that include the requirements is the use of projects.

Beth Schultz says that the assignment of individual projects is an excellent device which serves several purposes:

1. It gives flexibility to the program in that it offers opportunity to students of many interests and abilities.
2. It is a way of utilizing laboratory experiences within the difficult limitations of space, equipment, and schedules.

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[3]Paul F. Brandwein, Fletcher G. Watson, and Paul E. Blackwood, Teaching High School Science - A Book of Methods (New York: Harcourt, Brace and Company, 1958), p. 167.

3. It offers students the experience of doing real research study.[4]

Helen W. Boyd has the following to say about the purposes and uses of student projects:

> The use of student projects is another way of creating and maintaining interest. Such projects can be scaled to meet the need of both the weak pupil and of the superior student. Using these projects for participation in science fairs is an additional stimulus to the pupils. The Junior Academy of Science sponsors district, state and national science fairs in which these projects may be entered. As prizes to the winners, some offer cash awards, magazine subscriptions, and scholarships. A fair within the school for the selection of the projects for the district fair is quite helpful in sustaining interest. Science talent search, sponsored by the Science Clubs of America, is another national group which offers unusual advantages for the biology students, as well as other science students for project work.[5]

Helen W. Boyd also believes that projects are essential to good teaching techniques and can do much to broaden the interests and knowledge of the class. She requests that each student have some project dealing with biology. It is not necessarily a lengthy project, but rather one which can be completed in a few weeks time. Short term projects are easier for most students, as they need a short time lapse. Most students are unable to keep their attention on one thing for a long period of time.

Projects may be undertaken by individual students at home, especially in slow classes, or may be profitably done on class time by one entire group. An example used was that of a class of slow learners using

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[4]Beth Schultz, "Urban Biology - An Ecological Approach," The American Biology Teacher, Volume 22, No. 3 (March, 1960), pp. 147-152.

[5]Helen W. Boyd, Successful Devices in Teaching Biology (Portland, Maine: J. Weston Walch Publisher, 1957), p. 5.

modeling clay and soap to make models of prehistoric man and animals as a project. Some of the students constructed cave scenes, or made paintings or drawings showing early man.[6]

William Kastrinos states, "The project method of teaching is an ideal way to stimulate scientific thinking in high school students."[7]

However, there has been some strong opposition, which is based upon valid grounds, against the use of the project method of teaching. They include the following:

1. This is the most difficult method for the teaching, requiring more planning and more effort of execution.
2. If properly operated, it calls for somewhat more materials and equipment than the strictly demonstration method.
3. The amount of time consumed by the projects may be so great as to make it impossible to cover a wide variety of topics, thus resulting in an incomplete course.
4. It may result in a lack of proper coordination of subject matter when individualized, since students may be working upon problems or projects which may be part of the general subject; but each student may miss the relationship between all the parts.
5. Difficulties of the method increase in proportion to the number of students in large classes and in proportion to the number of classes per day which the teacher must have.[8]

Many of the disadvantages of project teaching can be overcome, and those teachers that use it are notably in favor of the method whenever it is possible to use it. Some of the advantages are

1. Though it is the most difficult method for the teacher, requiring more effort and planning, the lack of this effort is one of the reasons for much of the mediocre teaching that is done. The results of the method, when it is properly executed, more than compensate for the extra work that is required.

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[6] Louis Eisman and Charles Tanzer, Teacher's Manual and Key to Accompany Biology and Human Progress (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1958), p. 10.

[7] William Kastrinos, "Biology Projects for High School Students," The American Biology Teacher, Volume 18, No. 8 (December, 1956), p. 251.

[8] David F. Miller and Glenn W. Blaydes, Methods and Materials for Teaching Biological Sciences (New York: McGraw-Hill Book Company, 1938), p. 45.

2. The necessity for more materials and equipment is generally an excuse rather than a reason for not using the method. The problems and experiments can be so devised that they will require nothing that cannot be had at little or no expense. The providing of these materials might well become a part of the student's responsibility.
3. As to economy of time, there is much doubt as to whether time well spent upon less subject matter might not be worth more to the student than the same time spent in hurrying over more subject matter.
4. The lack of coordination which sometimes is the result of individual work is little more than the result of poor planning and lax execution upon the part of the teacher.
5. In no other method is there equal provision for those essential factors demanded by our objectives. The solving of problems is essential to the training in scientific thinking and the following of projects is a vital part of the production of these attitudes which should be the outgrowth of science teaching. Proper planning will provide for group or even class participation as a means of diminishing the problem of numbers of students and numbers of classes that must be taught and will still make possible a sufficient amount of independent work to provide for the necessary individualization.[9]

There are many situations conducive to critical thinking. They include:

1. Undertake an investigation of general class concern with the class organized as a research team. Some examples of this would be: a study of the amount of floor space of the various parts of the school building with reference to accepted standards and their uses; a study of a community problem such as the advisability of adding fluorine to the municipal water supply; a study of the Board of Health records for a city or county in relation to dairy products, restaurants, and food stores cleanliness.

2. Develop projects of relatively independent nature. Examples might be: the laboratory work in science can be based on project

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[9] Ibid., p. 46.

activity; local science fairs, the science achievement awards program, the Junior Academy of Science, and the Science Talent Search encourages project activity on a competitive basis.[10]

Where do young people get their projects? They come from many sources. Some that may be mentioned are consultations with teachers, with college and university scientists, with parents, and with research men in industry. One other way found very useful is in old and new editions of biological abstracts, chemical abstracts, and physical abstracts. Articles in the Scientific American, Science News Letter, The Science Teacher, The American Biology Teacher, The Quarterly Review of Biology, The Journal of Chemical Education, Physics Today, Science World, Popular Science and many other magazines contain many ideas. Also Future Scientists of America, Science Service (Westinghouse National Science Talent Search) and other organizations have helpful publications.[11]

Project work takes the time of interested people. Who is to sponsor it? It may be an interested teacher who willingly gives time to students before, during, or after school hours. Interested parents with special training, such as engineers, doctors, or technicians, may be sponsors. Scientists in the local industries or local university, or any responsible person who has time, ability and interest may sponsor the projects.[12]

Most high school students need help in the selection of a project

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[10] John S. Richardson, Science Teaching in Secondary Schools (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1957), p. 119.

[11] Brandwein, op. cit., pp. 193, 498, 499.

[12] Ibid., p. 498.

and a card file can be made which would contain ideas and suggest available source material. This card file can be enlarged from year to year. It usually works well for the teacher to make a list of suggested studies and have those suggestions specific. Some long term studies should be suggested as well as short term ones because some superior students may have an interest in some problem that could not be completed in a few weeks. For example, some nutrition studies could take several months. Also let the students suggest studies and problems that occur to them. Some of the most interesting problems arise from class discussions. Projects initiated by students are often the most valuable of all as they are the most challenging. Examples are: "How fast can an earthworm travel?" or "How long does it take for soil that an earthworm swallows to pass through the body?" All the suggestions should be such that they involve direct observation and/or experimentation. Always let the student modify the idea and adapt it to his own opportunities. Give the student some choice, that is, put him into a situation where he has to make some decisions. However, let this decision be within the range of his abilities and experience.

One or two class periods may be used for discussing the suggestions, and outlining the necessary steps of procedure. The steps will include: (1) selection of topic, (2) listing questions you hope will be answered as a result of the study, (3) making a tentative plan of procedure and schedule of observations and record-keeping, and (4) setting up a series of deadline dates. Last minute failure will be avoided if students are carefully checked at certain points along the way. Within a week after the assignment is given, each student should choose a project topic and formulate tentative plans. The student submits this in writing. The teacher should read these papers carefully and immediately, write comments and suggestions on them, and return the papers to the students within a few days. Then a series of dates for progress reports should be set. The teacher may ask for all of the material which the student has collected to date. This is a good indicator of how the student is progressing. From time to time some students may give oral reports to the entire class, as many of the students' studies will be quite interesting and worth showing.

The final report should be presented in some acceptable form. Perhaps it would be a good idea to ask for an outline a week or two before the final project is due. The final report may or may not be a lengthy paper. It may be a short summary accompanied by "the evidence"--the experimental material itself or a series of photographs or diagrams. The success of the teacher's assignment of individual projects will depend on the blending of flexibility along with careful, constant and specific guidance.[13]

Where do students get their special equipment needed? Usually a school administration or a parents' association will support a good teaching inventory. Industry and universities will offer equipment as well as advice. Many teachers thoughout the country have found that enormous potential aids are in the community. All that is needed is a sensible request for a desirable purpose. Sometimes the student, as a scientist, may be obliged to invent equipment or to organize available materials in a novel manner. The history of science is full of examples

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[13] Beth Schultz, op. cit.

where the invention of a new tool or a new procedure was the key to a major question.[14]

In giving this type of assignment, the teacher has the important responsibility to give guidance and at the same time to allow students to assume responsibility. The kind and amount of guidance is the key to success or failure of the assignment. The teacher must suggest studies, help students plan them, and help students pace their work so that something is accomplished. Lee R. Yothers has the following to say about the teacher's responsibility:

> The adviser can contribute by helping students to find interesting problems and by guiding their thinking to the desired solution. Also, the teacher can make available needed material which might otherwise be difficult for student procurement.[15]

Appropriate teaching materials may be accumulated by making a vertical file of magazine and newspaper articles, stories, pictures, periodicals, living and preserved specimens, industrial and governmental pamphlets and all types of multi-sensory aids. Permanent collections made by the student, models, slides, photographic prints, and charts can be added by the teacher year by year. Local resource people are a valuable teaching aid and also serve to bring the community and the school closer together. The teacher should also contact the biology department of the nearest state college. This will keep her in touch with expert biologists and new discoveries in this field and also make

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[14] Brandwein, op. cit., p. 193.

[15] Lee R. Yothers, "Biology Clubs and Projects," The American Biology Teacher, Volume 17, No. 3 (March, 1955), pp. 109-111.

available some of the resources of the college laboratory. Textbook specialists can help with new books and new methods they have found useful with their books.[16]

The teacher-student relationship is very important. The teacher is most effective when the relationship is good. It has been proven that emotional factors have a strong influence on the rapidity of student learning. The subject matter must be suitable to the maturity of the learner. In most instances a first hand learning experience is more effective than a vicarious one. Learning results from the interaction between an individual and his environment.[17] Dominating, authoritarian, or laissez-faire, unorganized teachers do not seem to hold the students' interest nor to have a great deal of success of teaching with projects.[18] Below there are listed some tips to teachers to be successful in the project method of teaching.

1. At the beginning of the school year, show your students some projects undertaken by former students. A discussion of the problems involved, methods of construction, working ability, potential value, and other pertinent facts may suggest new projects.
2. Arrange frequent and informal buzz sessions that will allow fellow students to predict, analyze, and solve problems related to individual student's projects.
3. Establish a working calendar. For example, the topics should be selected in October, progress reports in November, final sketches of plans by January, and tentative presentation of project by the middle of March.
4. Sometimes students can combine their interests with their art abilities and design a wall calendar. The birthdays of famous scientists can be marked and the dates of significant discoveries and inventions can be appropriately high-

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[16] Boyd, op. cit., pp. 5-6.

[17] Ibid., p. 7.

[18] Brandwein, op. cit., p. 193.

lighted. Most important of all, the dates of science fairs and award programs can be shown with progress stepping stones suggested that will help students meet deadlines.

5. To help students "scrounge" equipment and supplies, post a shopping list on which wanted items appear.
6. Prepare a roster of scientists in the community who can serve as special advisers or consultants to students who have problems and projects under way.
7. Prepare a roster of senior science students who will serve as special advisers or consultants for younger students. Don't overlook the upper elementary school students.
8. The advantages of individual work and team participation can be combined by having each student be captain of one team and participant in a second.
9. Attendance at a scientific lecture on some project a student is doing gives a great motivation toward its completion. Maintain a calendar of local scientific meetings.
10. Local productive or testing enterprises should be exploited for student project ideas.
11. As early in the school year as possible, science teachers should visit with all new students and find out any interests which can be directed toward project activities.
12. Science teachers can plan with industrial arts teachers for a recognized period during which students can have supervised opportunities to work in school shops.
13. Before students abandon a project or shift interest to a new one, teachers should try to help the student solve financial problems, remove equipment and construction road blocks, determine if the grass on the other side of the fence is really greener, and to salvage accumulated skill and experience for the new project.
14. Students appreciate seeing their projects used as teaching aids in regular classroom instruction.
15. Arrangements can sometimes be made between the science and English teachers that will allow a double period and an additional teacher to help in writing plans or reports of student projects.
16. Downtown store windows are sometimes available for weekly exhibits of good projects. An appropriate poster can solicit advice, equipment, or materials needed by other students.
17. Scientists' meetings, local, regional, and national, are good opportunities to share ideas for helping students to complete good projects.
18. Nearly every issue of all science teaching journals devotes some space to student project activities. Every school library should subscribe to <u>The Science Teacher</u>, <u>The</u>

Science Counselor, The American Biology Teacher, The Mathematics Teacher, School Science and Mathematics, Science Education, The Journal of Chemical Education, The Metropolitan Detroit Science Review, etc.[19]

Thus far we have discussed the teacher's role and responsibility in the making of projects. Now the student's responsibility, including what is a student project, and the do's and don'ts of doing a project, will be discussed. Actually a student project is simply a study of something--what it is and how it happened, is happening, or might have happened. The steps are not difficult and neither are they magical or mystical. Primarily a project should be a component of the biology student's learning process, useful in channeling student inquiries and actions into fruitful approaches to his biological training. If students are to receive full benefit from their experiences with projects, it is axiomatic that they acquire a storehouse of information about the problem which they have undertaken for solution. The students should be intelligently aware of the following four factors:

1. They must know what they want to do.
2. Is the solution of their problem possible or accomplishment by them?
3. They must know how their problem can and should be solved.
4. Upon completing their projects, the pupils should recognize or sense accrued values.[20]

In "If You Want To Do A Science Project" the following do's and don'ts of doing a science project are given:

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[19] If You Want To Do A Science Project (Washington, D. C.: National Science Teachers Association, 1955), pp. 18-19.

[20] Yothers, op. cit., pp. 100-111.

1. DO describe clearly what it is you want to explain or have happen.
2. DO as much reading about your problem as you have time for and give authors credit for what you borrow from them.
3. DO think ahead and list all of the difficulties that might develop and things that might influence your results.
4. DO keep progress notes. Include all of the ideas which come into your mind, notes on your reading and plans for experiments.
5. DO find ways to measure, observe, and record what happens to each thing that is involved in your project.
6. DO decide what you think is the most likely explanation of the thing that puzzles you or the most promising way to do what you want to do.
7. DO experiment to see if your guess is correct. Use the best controls you can arrange. Repeat your experiments.
8. DO go back to the third step if your first guess was wrong. See if you overlooked something. If you did, plan a new experiment.
9. DO repeat your experimenting until your problem is solved or you run out of time.
10. DO conclude your work with a statement of what you found out - whether you were right or wrong, succeeded or failed.
11. DON'T spend your money for materials and equipment until you see your way through your project.
12. DON'T waste time and enthusiasm on a project that is too big for you to tackle.
13. DON'T invest your enthusiasm in a project that requires room or facilities you can't arrange.
14. DON'T simply copy another student's project. It will turn out to be boring unless you can add a few new ideas of your own.
15. DON'T pick a topic that will take all of your time just to build the equipment.
16. DON'T get discouraged if your first guesses are wrong.
17. DON'T let a single experiment or one in which you used only a few examples fool you.
18. DON'T completely abandon a poor guess; salvage what you can learn from it to set your next guess up.
19. DON'T fail to talk over your project with your teachers, your parents, and scientists in the community. Give them credit for their help.
20. DON'T forget to check the grammar and spelling in your report.
21. DON'T overlook any chances to gain recognition for your work by entering your project in science fairs and award contests.[21]

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[21] _If You Want To Do A Science Project_, _op. cit._, pp. 6-7.

There are many different kinds or classes of science projects. You will find many examples of each class as you read science textbooks, laboratory manuals, and scientific magazines. According to Future Scientists of America, Student Projects, there are the following classes:

1. Development of a product.
2. Development of a process.
3. Building a device, instrument, or piece of equipment.
4. Development of new uses for materials, processes or devices.
5. Improvement of some material, process or device.
6. Testing and/or standardizing some product.
7. Determining market preference for some new product.
8. Studying a situation in which a scientific principle may be operating.
9. Trying to shed additional light on a scientific principle or to describe it more clearly.
10. Repeating a classical experiment.
11. Development of a new demonstration or visual aid that makes it easier to understand a scientific principle.
12. Finding out the way students learn science.
13. Examination of a local community productive process or enterprise.
14. Results of a survey, trip or library study as a broad basis for future action.[22]

After the project has been completed, it is necessary to share the results of the investigation with the other class members and the teachers. Some students write up their experiments for publication or prepare displays based on their projects for school and regional science fairs. Industrial and government laboratories provide their research men with detailed directions for reporting projects. Usually they avoid printed forms or "fill in the blanks" reports. Below is a suggested outline that provides direction, but allows for student freedom of

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[22] John H. Woodburn, Encouraging Future Scientists: Student Projects (Washington, D. C.: National Science Teachers Association, 1958), pp. 5-6.

expression as he prepares the report of his project.

Title

I. Summary
   A. Topic or problem investigated.
   B. The purpose of or reason for the investigation.
   C. The most important results or information gained from the investigation.
   D. Suggested action based on the results of the project.

II. Discussion
   A. Circumstances leading up to the project.
   B. Acknowledgement of help received from other people.
   C. Methods used in making the investigation.
   D. Conclusions and the reasoning upon which these conclusions are based.
   E. Argument for the suggestions or recommendations which grew out of the project.

III. Appended Materials
   A. Drawings, photographs, graphs, tables, maps, calculations, and other evidence supporting the project work and report.
   B. Other material dealing with the project.[23]

This completes the discussion on the importance and purposes of projects, the teacher's role and responsibility, and the student's role and responsibility in the making of projects.

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[23] *Ibid.*, p. 13.

CHAPTER II

SAMPLES OF PROJECTS

This section deals with examples of projects that students at the La Grove High School, Farina, Illinois, completed during the 1959-1960 school year under the writer's supervision. There are divisions of botany, miscellaneous, and zoology projects. There is a brief resume of each project, along with explanations and references.

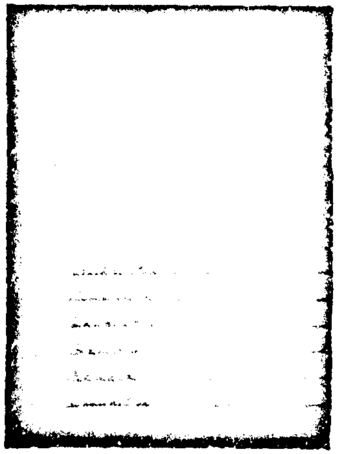

Figure A
Typical Page

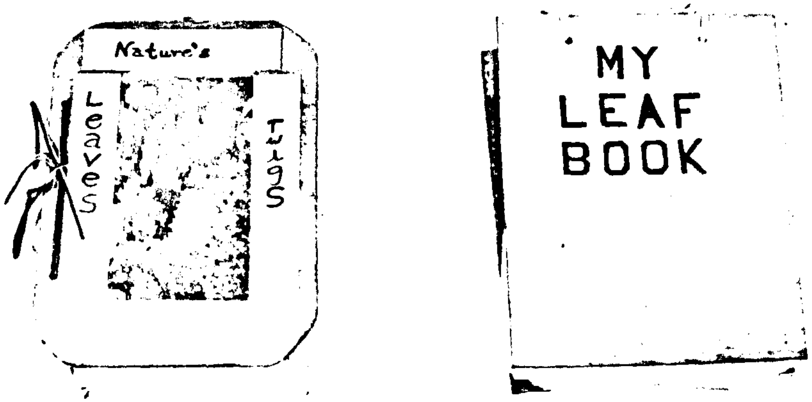

Figure B

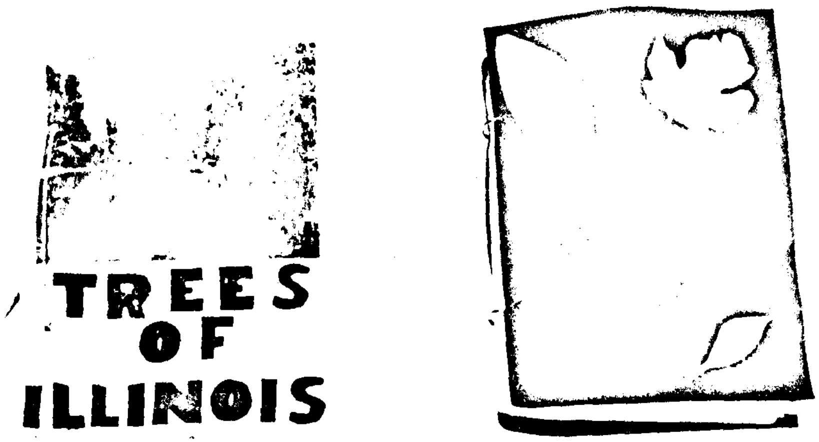

Figure C

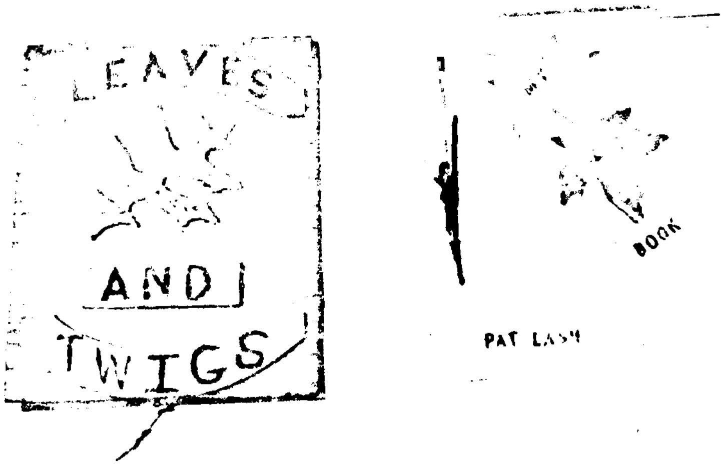

Figure D

A LEAF COLLECTION

A good method of identifying trees in a community is to make a collection of leaves of trees native in the area. Leaves of average size should be selected unless they are too large for the mounting sheet. Then smaller specimens will be appropriate, although those of average size must be used in identifying the tree. If the twig is not too thick, two or three leaves on a short twig should be taken. The leaf arrangement should be noticed and written on a piece of paper with notes on the habitat and the locality of the tree. This information should be wrapped around the leaves and placed in a box. Upon returning from the field trip, the leaves should be placed immediately in a drier. A drier that has been purchased from a biological house is excellent; but a homemade one of folded newspapers or smooth carpet paper cut to newspaper size may be used. Any notes taken while gathering the leaves should be put on a drier containing those leaves. A flat board may be used on top with some bricks or other weights. For the best specimens, the driers should be changed at least every two days, since they absorb water rapidly from the fresh leaves. For mounting the leaves, use rather heavy light-colored paper. A large scrapbook is excellent for mounting an entire collection. The leaves should be arranged on the sheets as artistically as possible and held in place with narrow strips of gummed paper, book tape, scotch tape, or adhesive tape across the petiole and leaf tips.

The paper with a label and data appears as Figure A on page 18. Also included in the book are common name index and scientific name index that are alphabetized. The sheets are placed in the book according to the common name of the leaf. Attractive covers decorate the front of each book as can be seen in Figures B, C, and D on page 18. Some references for tree identification are

Collingwood, G. H., and Warren D. Brush, Knowing Your Trees. The American Forestry Association, Washington, D. C.

Gray, Asa, Manual of Botany. American Book Company, Cincinnati, Pleasant, Iowa.

Jacques, H. E., How To Know The Trees. Published by Author, Mt. Pleasant, Iowa.

Mathews, F. Schuyler, Fieldbook of American Trees and Shrubs. G. P. Putnam's Sons, New York.

Trees. U. S. Government Printing Office, Washington, D. C., 1949. pp. 763-832.[24]

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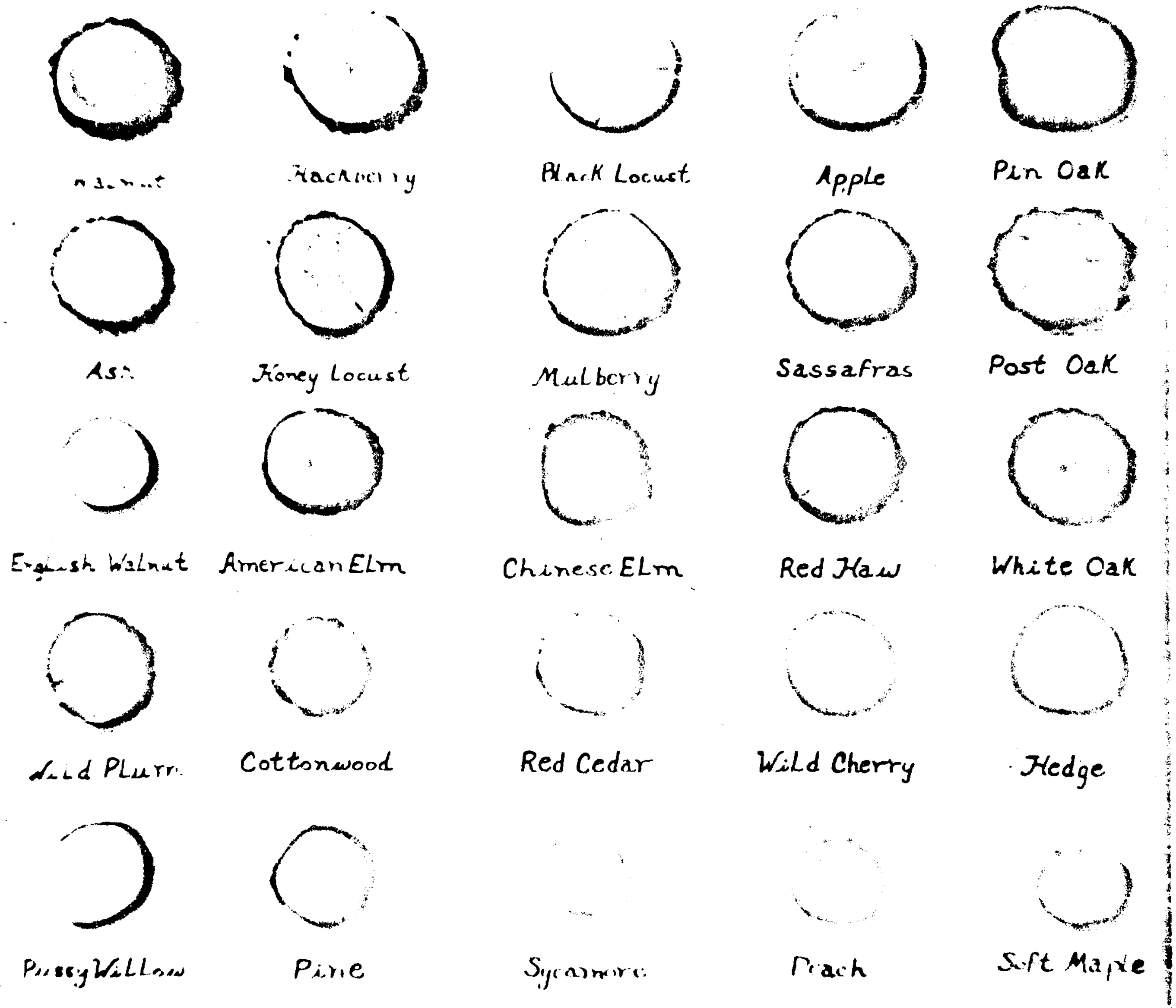
[24] B. B. Vance, C. A. Barker, and D. F. Miller, Biology Activities (Chicago: J. B. Lippincott Company, 1954), pp. 247-251.

WOOD CUTTINGS



NATIVE WOODS

Native tree woods may be split or sawed and mounted to show both the bark and inner surfaces. Sections of finished woods used for lumber and for furniture make interesting displays. Each specimen should be labeled with the common name, the scientific name, the habitat, the average height, the distribution and the uses of the wood.[25] A sample of a wood cutting project is found on page 21.

References:

Cheyney, E. G., What Tree is That? D. Appleton-Century Company, New York, New York.

Curtis, C. C., A Guide to the Trees. Garden City Publishing Company, New York, New York.

Dean, F. W., Ohio Trees. Agricultural Extension Service, Ohio State University, Columbus, Ohio.

Fuller, George D., Forest Trees of Illinois. Department of Conservation, Division of Forestry, Springfield, Illinois.

Gray, Asa, Manual of Botany. American Book Company, Cincinnati, Ohio.

Jacques, H. E., How to Know the Trees. Published by Author, Mt. Pleasant, Iowa.

Keeler, Harriet L., Our Native Trees and How to Identify Them. Charles Scribner's Sons, New York.

Mathews, F. Schuyler, Fieldbook of American Trees and Shrubs. G. P. Putnam's Sons, New York, New York.

Shaffner, John H., Field Manual of Trees. R. G. Adams and Company, Columbus, Ohio.

Trees. Washington, D. C.: U. S. Government Printing Office, 1949. pp. 833-854.

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[25] B. B. Vance, C. A. Barker, and D. F. Miller, Biology Activities (Chicago: J. B. Lippincott Company, 1954), p. 252.

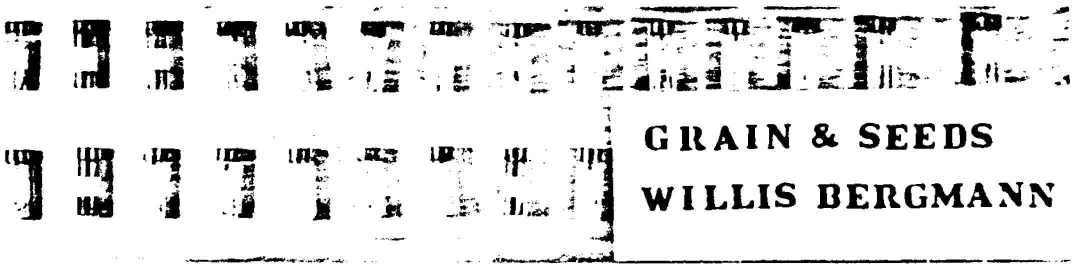

Figure A

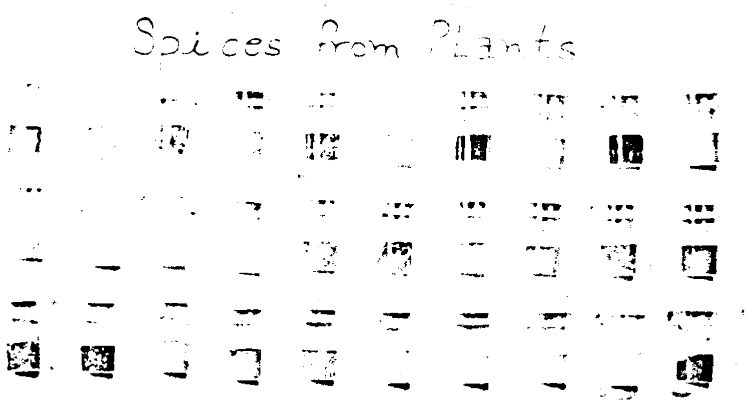

Figure B

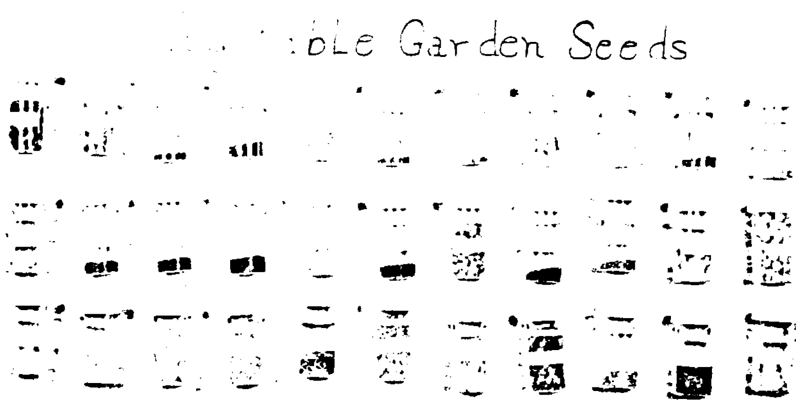

Figure C

NATIVE GRAIN AND SEEDS

Seeds may be put in openings cut in cardboard or plywood and covered with cellophane or sealed in small vials or bottles. They may be labeled with common name, scientific name, locality raised, habitat, remarks, collector, and date. Good references include: current seed catalogs, elevator men, and encyclopedias.[26] Samples of these projects are Figures A and B, page 23.

SPICES OBTAINED FROM PLANTS

The spices may be put in small bottles and fastened on plywood. They may be labeled with common name, scientific name, locality, habitat, part of plant used, collector, and date.[27] Perhaps data as to how prepared for commercial use should be included. Those spices used in the present collection, Figure C, page 23, include: allspice, anise seed, basil leaves, bay leaves, caraway seed, celery seed, chili (pepper) powder, cinnamon, cloves, curry powder, dill seed, garlic salt, ginger, ground mace, leaf marjoram, mint leaves, mustard seed, nutmeg, oregano leaves, paprika, parsley flakes, black pepper berries, cayenne pepper, red pepper, poppy seed, sage, sesame seeds, thyme and turmeric powder. Each one was checked separately in the encyclopedia to get the needed information.

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[26] B. B. Vance, C. A. Barker, and D. F. Miller, Biology Activities (Chicago: J. B. Lippincott Company, 1954), p. 252.

[27] Ibid.

WILD FLOWER PROJECTS

Apparently girls are always interested in flowers. There are shown on page 25, Figures A, B, and C, three different posters done by girls interested in wild flowers. The proper conservation of our wild flowers, along with their appreciation, should be taught.

References:

Hausmann, Ethel Hinckley, Beginner's Guide to Wild Flowers. G. P. Putnam's Sons, New York, New York.

Mathews, F. Schuyler, Fieldbook of American Wild Flowers. G. P. Putnam's Sons, New York, New York.

CLASSIFICATION OF FRUIT

Weed fruits may be mounted by fastening them to a display card. They may be labeled with common name, scientific name, locality, habitat, kind of fruit (for example, dehiscent--follicle), collector, and date.[28]

The classification of fruit found on page 27 was done during the winter, thus pictures were used instead of the actual fruit specimens.

Reference:

Holman, Richard M., and Wilfred W. Robbins, A Textbook of General Botany. John Wiley & Sons, Inc., New York, New York.

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[28] B. B. Vance, C. A. Barker, and D. F. Miller, Biology Activities (Chicago: J. B. Lippincott Company, 1954), p. 252.

POISONOUS PLANTS

Poisonous plants poster, page 29, is an outgrowth of plants that are harmful and/or poisonous. A report on poisonous plants was given by the student completing this project. The three that she drew were poison ivy, poison oak, and poison sumac.

Reference:

B. B. Vance, C. A. Barker, and D. F. Miller, Biology Activities. J. B. Lippincott Company, Chicago, Illinois.

MEDICINAL DRUGS

This is a collection of common plant parts that are used in medicine. The collections made on page 31, Figures A and B, include the following: Aconite root, Acornus rhizome, Agaric, Aloe, Aloin, Anethi fructus (dill), Arnica flower, banana starch, Belladonna leaves, Bloodroot, Buckthorn bark, whole Buchu leaves, Cannabis sativa, Caraway seed, Cascara sagrada, corn, Larkspur seed, whole rice, pumpkin seed, celery seed, Cassava, Claviceps purpurea, Cinnamon, Cloves, Coco leaves, Cinchona root, Columbo root, Cud Bear, wheat, Datura, Digitalis, Eucalytus powder, Ginger, Gossypium, Guarac wood, Hyoscyamus powder drug, Hydrastis canadensis, Horehound, Irish moss Chondrus, garden allspice, juniper berries, Maranta starch, yeast, cassia cinnamon, mint leaves, Kamala, Mustard, Nepeta cataria, Nux vomica, oats, Penang Cloves, Podophyllum, Prunus fruit, shot pepper, Quilliaja, rye flour, American Saffron, Sandrac gum, Tennerelly Senna, parsley Seed, Garlic allium, Aspidium rhizome, Scoparius cytisus, Alexandria senna, Telicherry Pepper, Rhamnus fragula, Squill, Uva ursi, wheat flour, cherry bark, Tumeric, Blue Flag rhizome, and Orris root. A special thank you should be given to the local pharmacist and medical doctor for their assistance with these projects.

Reference:

Goodman, Louis, and Alfred Gilman, The Pharmacological Basics of Therapeutics. The MacMillan Company, New York, New York.

SOIL TESTING WITH PLANTS

In the spring, the thoughts of everyone turn toward growing something. This spring several of the students decided to test soils and grow plants. They were to use local garden soil that had not been fertilized recently, sand or clay from local fields, and soil that contained commercial fertilizer. The ratio for the commercial fertilizer was one tablespoon to a one pound can of soil. Three different types of fertilizers were used. They were: 12-12-12, containing 12% nitrogen, 12% potash K_2O, 12% available phosphoric acid; 6-12-12, containing 6% nitrogen, 12% potash, 12% available phosphoric acid; and 4-16-16, containing 4% nitrogen, 16% potash, and 16% available phosphoric acid. The plants used were marigolds, zinnias, tomatoes and cabbage.

It was apparent to the students that fertilizing the soil produced superior plants (see pictures on page 33). The class was interested to find that the tomato plants in fertilized soil were darker green in color and had sturdy stems, but died within two weeks. Evidently too much fertilizer is as bad as not enough in some cases. Different kinds of plants require different concentration of fertilizers. This adverse effect did not prove true in the case of the other specimens. The plants were under examination for five weeks.

HYDROPONICS

Hydroponics is the growing of plants without soil by the use of chemicals in water. One needs distilled water, tap or well water, three eight-inch flowerpots of about one-half gallon capacity, fine gravel or chat, three one-hole cork or rubber stoppers, glass and rubber tubing, vegetable or flowering plants, two half-gallon fruit cans, wide board, two bricks, auger and large bits, baking pan, potassium nitrate, monocalcium phosphate, magnesium sulfate (Epsom salts), iron sulfate, paraffin, and gasoline. The apparatus should be set up as shown in Figure A on page 35.

One should use glazed flowerpots if possible, or coat the outside of ordinary pots with a mixture of gasoline and paraffin, and firmly insert the stoppers and tubes. A hole is punched near the top of each fruit can to hang it at the side of the window. The pots are filled with coarse washed gravel or chat. In each, one or more young plants or rooted cuttings are set deep in the material. Potatoes, sunflowers, begonias, coleuses, carnations, or roses may be used successfully.

Tomatoes were used in the experiment. They were about six inches high when placed in the pots. In the can connected with Pot A the following solution was put:

Potassium nitrate	0.05 oz.	(1.4 g.)
Monocalcium phosphate	0.025 oz.	(0.7 g.)
Magnesium sulfate (Epsom salts)	0.04 oz.	(1.1 g.)
Iron sulfate	1/20 teaspoon	(0.2 g.)
Distilled water	1 quart[29]	

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[29] E. B. Vance, C. A. Barker, and D. F. Miller, <u>Biology Activities</u> (Chicago: J. B. Lippincott Company, 1954), p. 81.

In the pan connected with Pot B, 1 quart of well or tap water was added. The well water used had a large amount of iron in it as well as other chemicals.

In the can connected with Pot C, the Turtox chemical set (purchased from General Biological Supply House, Chicago, Illinois) for water culture was used. There were four small jars of chemicals, labeled Unit I, Growth Salts A; Unit I, Growth Salts B; Unit II, Trace Salts; and Unit III, Iron Sulphate. Unit I, Growth Salts A, was a homogeneous mixture of:

Monopotassium phosphate	10.62 g.
Magnesium sulfate	19.26 g.
Ammonium sulfate	3.24 g.

Unit I, Growth Salts B, contained 36.18 grams of calcium nitrate. The small bottle that contained eighteen cc. of Unit II, Trace Salts, was made up by dissolving in a pint of water, 0.8 grams each of boric acid, manganese sulfate, and zinc sulfate. Six cc. was the quantity of this solution required for making up three gallons of the nutrient medium. The fourth vial, labeled Unit III, Iron Sulphate, contained 1.38 grams of iron sulphate dissolved in a small amount of water. The contents of this vial was added to one-half gallon of water to make the dilute solution which was added to the nutrient medium as required. In the beginning, 60 cc. was added to the three gallon lot of nutrient solution. Later, a few cc. was added every few days. The student "fed" the plants five times daily throughout the time of the experiment.

As you can see, from the picture, the best results were obtained from the Turtox chemical set. However, the Pot A results were satisfactory with the laboratory mixed chemicals.

The experiment took eight weeks and when school was closing only the plants in A and C were blooming. The student continued the experiment and has raised some small tomatoes on all of the plants, after eleven weeks.

References:

Ball, Victor, Gravel Crops. George J. Ball, Inc., West Chicago, Illinois.

Conners, C. H., and V. A. Tiedjens, Chemical Gardening for the Amateur. William H. Wise Company, New York, New York.

Martin, D. R., Growing Plants Without Soil. Chemical Publishing Company, Inc., New York, New York.

Soilless Plant Culture in the Biology Laboratory. Turtox Bulletin, General Biological Supply House, Inc., Chicago, Illinois.

Tottingham, W. E., Crop Production without Soil. University of Wisconsin, Madison, Wisconsin.

Withrow, R. B., and J. P. Biebel, Nutrient Solution Methods of Greenhouse Crop Production, Circular 232. Department of Horticulture, Purdue University, Lafayette, Indiana.

GRAFTING

Grafting is always an interesting project. One of the favorites is that of grafting a potato and tomato together by "inarch" grafting. Inarching consists of bringing together branches from two whole plants. When the stems are about eight to ten inches high, a portion of each should be cut away to expose the cambium and the faces should be bound together (see Figure C, page 35). This method is useful when the union is difficult to make since both the stock and scion retain their own roots and leaves until the union is complete. Raffia, waxed string, or grafting tape may be used to bind the parts together. Care must be taken to prevent the binding from strangling the graft when the parts begin to grow. Cover the wounded area with paraffin, grafting wax or clay. This reduces evaporation from the cut surfaces and prevents fungus spores from entering the wound. The development of modern plastics has brought a group of synthetic compounds and tapes into prominent use, often displacing the older grafting waxes.

Miller and Blaydes give the following recipe for the making of grafting wax:

> Grafting wax is made of 4 parts (by weight) of rosin, 2 parts beeswax, and 1 part beef tallow. The whole mixture is melted by heating. Pour the melted mass into cold water. When cool enough to handle it should be kneaded and pulled, as taffy is, or until it becomes a creamy-brown color. To apply to a graft, press it into the crevices, covering all the cut surface.[30]

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[30] Miller and Blaydes, op. cit., p. 385.

The *American Peoples Encyclopedia* tells of a softer wax which may be applied with a brush when warm.

> It consists of five pounds of resin, one pound of beeswax, one-fourth pint of linseed oil, and one-half pound of lampblack or powdered charcoal. Adding the ingredients separately lessens the danger of fire which might occur if the mixture boils over.[31]

The growth was allowed to continue for five weeks by which time union between the two stems had occurred. After the union was established, the upper part of the stock (the potato) and the lower section of the scion (the tomato) were removed by two cuts. The tomato stem grew on the potato and received its water and minerals through the potato roots. The lower portion of the potato stem and its roots obtained food from the tomato leaves. The plant that is left can produce both tomatoes and potatoes (Figure 8, page 35).[32]

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[31] "Grafting", *The American Peoples Encyclopedia*, Volume IX, pp. 9-775.

[32] R. B. Vance and D. F. Miller, *Biology For You*, (Chicago, Illinois: J. B. Lippincott Company, 1954), p. 583.

HEREDITY STUDY OF PEAS

The section on heredity can be either for plants or animals, however, the problem that is worked out on the charts is on smooth skin and wrinkled skin in peas.[33] The student used actual pea samples, but the wrinkled peas did not photograph well. They were too light in color and faded into the background.

YEAST IN BREAD MAKING

During the study of fungi, a project on breadmaking is always done. One batch of bread ingredients is mixed up, but no yeast is added. Naturally the bread does not raise and it is a very hard untasty mass when baked. This year, the student made one batch with dry yeast and another batch with compressed yeast, to compare the two different types of yeast.[34] The conclusion was reached that either type was satisfactory and the preference of the baker would be the deciding factor. Any good recipe cookbook contains suitable recipes for the making of bread.

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[33]Vance and Miller, op. cit., p. 510.

[34]Ibid., pp. 214-215.

A CHANGEABLE ELECTRIC BULLETIN BOARD

The electric bulletin board may be designed with some interesting innovations. Our bulletin board was built by two students, Don Folk and Louis Wolf, Jr., with the teacher purchasing the needed materials.

This electric bulletin board (page 42) has a varnished plywood base, with transparent envelopes in which the pictures and names may be placed. Electric lights were placed under the pictures and switches under the names. If the correct switch is connected, the light under the picture lights. The wires connecting the pictures to the names are extra long, so that they may be changed now and then to prevent mere memorization of a sequence pattern.

There is room for thirty-nine small pictures and names. We have found this large enough to be challenging and not so large as to be discouraging. An outstanding feature of this electric bulletin board is that it can be changed frequently by either a student or the teacher. A change every ten days to two weeks provides enough time for the student to gain proficiency on a set this large, and for them to enjoy showing others how well they have conquered a set.

Small pictures are pasted on posterboard cut to size 4" x 5" cards, and the correct names are written on the backs of the cards for filing purposes. The names for the board are printed or typewritten in capital letters on strips of posterboard 1½" x 4". When the display is changed, cards of that particular set are placed in an envelope, labeled, and filed for use the next year. Collections such as leaves, insects, sea shells, and twigs may be pinned to the board and identified similarly.

This sort of identification is lacking in many of our biology textbooks and the changeable electric bulletin board is one of the many aids which can be used to help meet this interest and need.[35]

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[35]Paul V. Webster, "A Changeable Electric Bulletin Board," The American Biology Teacher, Volume 16, No. 1 (January, 1954), p. 24.

DISEASES

The Malaria Fever Parasite Cycle poster on page 45 was made by a student who was very interested in malaria. One of her brothers had contracted malaria while in the service.

Diseases are an important area of study in biology. The students should be taught how to prevent getting a disease, as well as the standard treatment of a disease after it has been contracted. Most students secretly worry about their health and a good program of education can go far to dispel the fears and superstitions.

Any good biology or health books are excellent to obtain valuable information. This drawing was taken from Biology For You by B. B. Vance and D. F. Miller (Chicago: J. B. Lippincott Company, 1954).

HEALTH

Health is an important area of study in biology. Everybody needs to know how to take care of their health. Laboratory work could consist of examining some animal parts (for example, lung and trachea), have oral reports on diseases, demonstrations (like artificial respiration), and the making of posters. Four of the health posters are shown on page 47. The students made an oral report before the class on their topic and did a drawing to show some area of their interest. References are biology and health textbooks.[36]

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[36] Helen W. Boyd, Successful Devices in Teaching Biology (Portland, Maine: J. Weston Walch Publisher, 1957), p. 93.

FIRST AID

The next project has to do with a series of posters on first aid, pages 49 and 50. Everyone needs to know first aid so they will know what to do when an emergency arises. As you know, first aid is "the temporary care of an injured or sick person by simple common sense methods, based on what a doctor knows and could do, but applied by a person not professionally trained in medicine or surgery."[37]

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[37]Vance and Miller, op. cit., p. 436.

LANDSCAPING A HOME

Jerry Brasel, the student who did this project, is very interested in becoming a landscape architect. He wanted to try his hand at landscaping a model home.

He built a model home, page 51, and placed it on a piece of masonite. He mixed plaster of paris and dirt to make the lawn, a dyed sponge for the chimney, hedge and artificial flowers in the flower beds. Pieces of bittersweet became two trees and pieces of cedar, spruce, and pine were used for other plantings. A maple twig became another tree.

The rules for landscaping that he tried to follow were

a. Plant in groups and leave large open spaces.
b. Plant next to buildings and fences, with the taller shrubs at the back.
c. Plant trees far enough apart that they will not shade the lawn too much.
d. Do not set trees in lines, but rather at irregular intervals to seem as natural as possible.
e. Use a variety of early and late blooming shrubs for continuous beauty.[38]

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[38] Vance and Miller, op. cit., pp. 598, 614.

LANTERN SLIDES

The making of lantern slides can be of great benefit to the biology department. They can be made on any area of biology and kept from year to year.

Prepare a mixture of four drops of Canadian balsam in twenty-five cc's of xylene. Mix well and paint the mixture on a lantern slide, and let dry. Paint the picture and labeling with India ink.[39]

Some lantern slides made in this project are found on pages 54 and 55.

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[39] Dr. Walter M. Scruggs, Eastern Illinois University, Charleston, Illinois, Directions and Recipe.

PLASTER OF PARIS MODEL OF SHEEP'S HEART

A fascinating subject is the making of model figures that help to tell a story in a life-like way. Most of us are not sculptors, so we cannot mold a figure out of clay or carve it from soap and make it look realistic. However, by learning to make casts of things (such as leaves, snakes, lizards, frogs and parts of animals--for example, the heart), one can make models that will look as good and professional as anything a real expert could do with clay or soap.

Plaster of Paris can be bought in most drug stores very cheaply. As it is cheap and simple to use, the beginner should practice with plaster molds before he tries other materials. We used a preserved sheep's heart, as the fresh product that was obtainable was not suitable. All of the excess fat was carefully removed and the aorta, arteries, and veins left in their proper places.

A box, a little larger than the specimen, was obtained to make the cast. A pottery bowl was filled with the correct amount of water (practice will teach one this amount). Some kind of coloring matter (red, blue, or yellow tempera paint) should be used so the difference between the plaster mold and the model cast can be told easily. We poured Plaster of Paris into the bowl until it came just slightly above the surface of the water and began to form cracks like mud. We mixed until the plaster took the form of a smooth and thick paste. We poured a layer of an inch or two thick of creamy plaster in the bottom of the box. The sheep's heart was carefully placed in the middle of the box and the remaining plaster poured on top. The plaster mold was allowed to harden, which took about one-half hour, before moving. The plaster mold was allowed to dry twenty-four hours and then sawed into two sections. The sheep's heart was carefully removed and the plaster mold allowed to dry thoroughly. See Figures B and C on page 57.

The following steps were taken in making the plaster model. The inside of the mold was coated with liquid vaseline, so that a thin film was left on the surface. This was allowed to dry. It prevented the model or cast from sticking to the mold. The plaster mix was as described above and poured slowly in the mold. When the mold was filled with plaster, it was allowed to set. The cast was removed from the mold and allowed to cure. After curing, the cast was carefully washed with water and detergent to remove the vaseline. When dried thoroughly, it was ready for painting and mounting - see Figure A, page 57.[40]

Reference:

Vinson Brown, How to Make a Home Nature Museum. Little, Brown, and Company, Boston, Massachusetts, pp. 104-143.

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[40]Dr. Walter M. Scruggs, Eastern Illinois University, Charleston, Illinois Gave Directions and helped with the Project.

MODELS OF SOIL CONSERVATION PRACTICES

Conservation education is an appreciation of the significance of the study of our natural environment with a concern for efficiency in the development and management of these resources.

For soil conservation practices, models can be made to illustrate terrace farming, strip cropping, gully control, storage reservoirs, properly planned tree cutting, trees for windbreak, contour farming, run-off control, grass waterways, and proper formation of a lake. One will need soil boxes 18 to 24 inches square and six inches deep (one for each conservation practice shown) or a large soil or sand table; straw, or other devices for representing crops. One student used artificial Easter basket grass to represent vegetation. Bits of evergreens such as cedar, spruce, or pine may be used to represent trees. For example, one should proceed for strip cropping (Figure E, page 61) and contour farming (Figure B, page 60) by preparing a gentle slope in the soil box. The soil slopes from back to front about half the length of the box and from right to left in the left half of the box. This will form a low hill with slopes in two directions. Each slope is divided into strips, about two inches wide, which follow the contour of the hill. Crops may be indicated with pieces of straw painted different colors with poster paint if one wishes. Other devices may be used to represent crops of different kinds. In "planting" the crops in the different strips, use row crops (with straws set in straight rows one-quarter to one-half inch apart) in some strips and cover crops (with straws scattered through the strip) in others. Row crops and cover crops are alternated. Indicate the system you use in identifying various crops.[41]

References:

It's Your Top Soil, American Steel and Wire Division, United States Steel, Rockefeller Building, Cleveland 13, Ohio, 1947.

Soil Conservation. John Deere Farm Equipment Company, Moline, Illinois, 1958.

Walker, Ernest D, and Albert B. Foster, *This is Our Soil*. The Interstate Printers, Danville, Illinois, 1951.

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[41] James H. Otto and Sam S. Blanc, *Biology Investigations* (Chicago: Henry Holt and Company, 19[illegible]6), p. 310.

B. K. Barton, *Illinois Resource Management Teaching Conservation* (Springfield, Illinois: Conservation Education, Office of Public Instruction, 1959), p. 7.

B. B. Vance and D. F. Miller, *Biology For You* (Chicago, Illinois: J. B. Lippincott Company, 1954), p. 574.

STATE PARKS OF ILLINOIS

State Parks of Illinois.

ILLINOIS STATE PARKS AND MEMORIALS

The purpose of this project was to teach and learn something about the wildlife preserves, refuges, parks, and memorials in our state. The student who completed this project made a detailed study of Illinois state parks and memorials, as well as drawing a map of Illinois, page 64. The map has the counties outlined and each state park, refuge, or memorial is placed in its proper place. She collected a series of pictures and articles about the various state parks and presented a very interesting and worthwhile report to the class.[42]

Reference:

Palmer, Glen D., Illinois State Parks, Memorials, and Conservation Areas. Department of Conservation, Division of Parks and Memorials, Sixth Edition. State of Illinois, Springfield, Illinois, 1958.

[42] James H. Otto and Sam S. Blanc, Biology Investigations (Chicago, Illinois: Henry Holt and Company, 1956), p. 312.

THE RELATIONSHIP OF LIVING PLANTS AND ANIMALS

This includes the relationship between all living things. The earth's store of natural resources can provide health and wealth for all--if wisely used. It is necessary to teach about these relationships so that present and future generations may appreciate the cultural and finer things of life. Two posters, Figures A and C, page 66, help to show the interrelationship.[43]

THE EVOLUTION OF HORSES

Figure B, page 66, illustrates the changes that have occurred in horses through the ages. Every biology textbook discusses the changes that have taken place in evolution. This poster is a display item that went along with a speech given as a sample of evolution in an animal that we know about.[44]

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[43] Vance and Miller, op. cit., pp. 533-573.

[44] Ibid., pp. 511-531.

ANIMAL KINGDOM

During the school year we do a detailed study of the animal kingdom beginning with Protozoans and finishing with the Chordata. One of the students was very interested in the progression from the simplest to the most complex animals. She made the poster on page 68 to represent the various phyla. For example--amoeba for Protozoa, simple sponge for Porifera, jellyfish for Coelenterata, sheep liver fluke for Plathyhelminthes, vinegar eel for Nemathelminthes, starfish for Echinodermata, clam for Mollusca, earthworm for Annelida, crayfish for Arthopoda, fish and bird represents the Chordata.[45]

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[45] Vance and Miller, op. cit., p. 251.

PROTOZOAN CULTURE

Helen W. Boyd states in her discussion of the study of Protozoans that "drawings of five to ten typical Protozoans"[46] should be done. This drawing of typical Protozoans was taken from Vance and Miller's book, Biology For You, page 253.

The student saw several different Protozoans in her hay infusion. It was prepared by taking several handfuls of dead grasses and weeds from the edge of a pond. The ingredients were placed in a jar of water and allowed to stand in a warm area for about two weeks. She mounted drops of the water on a slide and examined it under both low and high power of the microscope. Her report to the class on Protozoans was outstanding in its presentation of their life, habits, food, habitat, and responses.

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[46] Boyd, op. cit., p. 52.

SEA SHELL COLLECTIONS

Another interesting project is the collection and display of sea shells.[47] Two interesting displays are shown in Figures A and C on page 72.

References:

Hausmann, Leon A., Beginner's Guide to Seashore Life. G. P. Putnam's Sons, New York, New York.

Miner, Roy Waldo, Field Book of Seashore Life. G. P. Putnam's Sons, New York, New York.

Peterson, Roger Tory, A Field Guide to the Shells. Houghton Mifflin Company, Boston, Massachusetts.

Verrill, A. Hyatt, The Shell Collector's Handbook. G. P. Putnam's Sons, New York, New York.

Zim, Herbert S., Seashores: A Guide to Animals and Plants Along the Beaches. Simon and Schuster, New York, New York.

Figure B on page 72 shows a collection of native Illinois snails that had been collected.

Reference:

Eddy, Samuel, and A. C. Hodson, Taxonomic Keys to the Common Animals of the North Central States. Burgess Publishing Company, Minneapolis, Minnesota.

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[47] James H. Otto and Sam S. Blanc, op. cit., p. 172.

CLAMS (THE PELECYPODA)

The clams found in the collection of page 74 were taken from the Kaskaskia, Wabash, and Embarrass Rivers in Central Illinois. The different types of shells, along with the varied formations, proved most interesting.

Reference:

Eddy, Samuel, and A. C. Hodson, Taxonomic Keys to the Common Animals of the North Central States. Burgess Publishing Company, Minneapolis, Minnesota.

INSECT COLLECTION

One of the most common biology projects is an insect collection. Insects outnumber all other forms of life nearly everywhere. Insects that fly are easily caught in a net. Directions for making a net can easily be found in a biology textbook or a laboratory manual. There are three usual forms of killing bottles which include cyanide (very poisonous), carbon tetrachloride, or chloroform. A harmless and yet quite efficient killing bottle is made by using torn-up blotters in the bottom of a jar and saturating them with carbon tetrachloride. The fumes will quickly kill the insect. The insects should be mounted on pins as soon as possible after killing. If left in the killing jar they will remain relaxed and soft for several days, but some insects' colors fade in the fumes. To mount most insects, a pin is put through the thorax from above, leaving about one-half inch of the pin above the back. Any slender, straight pins or Japanned insect pins may be used. Very small insects such as ants, gnats, and aphids, should be mounted in a drop of glue or shellac at the tip of a small triangle of cardboard, heavy paper, or celluloid. Insects belonging to the same order should be placed together. All should face in the same direction and be spaced according to size. The wings of butterflies, moths, dragonflies, and similar insects should be spread out at right angles to their bodies. This should be done just after pinning, since the wings set if allowed to dry out. Spread only the left wing and wing cover of grasshoppers, katydids, and crickets.

A small label should be placed on the pin beneath each insect. Labels should all be on the bottom of the box or an equal distance from the bottom. Print all the information on the labels using black ink. Order names may be found in any good insect key. The label should look like this:

Order
Scientific Name
Common Name
Collector Date

Display cases may be homemade boxes or if there is not time or money to make a box, secure a cardboard box about three inches deep. A candy or cigar box is satisfactory. For any type of box, make a false bottom of corrugated cardboard, fiber insulating board, cork, or paraffin to receive the pins. Cut to fit smoothly and line the whole box with white paper. The finished collection should be protected from pests that like the dead bodies of insects by placing naphthalene flakes, moth balls, or paradichlorobenzine in a cloth bag in one corner of the box.[43]

References:

Klots, Alexander B., A Field Guide to the Butterflies. Houghton Mifflin Company, Boston, Massachusetts.

Lutz, Frank E., Fieldbook of Insects. G. P. Putnam's Sons, New York, New York.

Morgan, Ann H., Fieldbook of Ponds and Streams. G. P. Putnam's Sons, New York, New York.

Sterling, Dorothy, Insects and the Homes They Build. Doubleday and Company Inc., Garden City, New York.

Swain, Su Zan N., Insects in Their World. Garden City Books, Garden City, New York.

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[48] Vance, Barker and Miller, op. cit., pp. 245-247.

Swain, Ralph B., _The Insect Guide_. Doubleday and Company, Inc., Garden City, New York.

Zim, Herbert S., and Clarence Cottam, _Insects_. Simon and Schuster, New York, New York.

SKELETAL SYSTEMS

The skeleton is one of the most interesting parts of the vertebrate body, since it is intimately associated with every activity of the animal. This framework can be understood only in the light of the knowledge of the long series of changes through which the vertebrate animals developed.[49]

The skeletons of the chickens and pigeons were prepared by removing the feathers, most of the meat, and the viscera. They were then cooked in boiling water to which a tablespoon of detergent had been added. That helped to remove the grease from the bones. After removing the remaining meat, the bones were soaked in a weak solution of hydrogen peroxide to bleach them. Then the bones were carefully replaced and attached to make a finished skeleton. See page 80, Figures A and B.

The parts of the endoskeleton of vertebrates are the skull; the branchial skeleton, composed of gill arches supporting the gills; the vertebral column, occupying the median dorsal region; the ribs, projecting from the vertebrae; the sternum, occupying the median ventral region of the anterior part of the trunk; the pectoral girdle, supporting the anterior paired appendages; the pelvic girdle, supporting the posterior paired appendages; and the skeleton of the appendages. The four parts first named constitute the axial skeleton, while the other parts constitute the appendicular skeleton.[50]

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[49] Leverett Allen Adams, An Introduction to the Vertebrates (New York: John Wiley and Sons, Inc., 1938), p. 71.

[50] Libbie Henrietta Hyman, Comparative Vertebrate Anatomy (Chicago, Illinois: University of Chicago Press, 1942), p. 99.

AVIAN SKULLS

The skulls of birds are very light and pneumatic, with a tendency for all the individual elements to fuse into one piece, except the quadrates. They remain free and movable. Modern birds have the jaws encased in a horny beak, resembling that of the turtles.

The skull is tropibasic - the jaws are loosely articulated with the skull - and since the quadrates are free, is streptostylic - referring to a section of the reptiles having quadrates loosely articulated with the skull, as in lizards and serpents. The brain case is large. The foramen magnum is inclined ventrally and in owls and hawks its position is clearly ventral. The occipital condyle is formed by the basioccipatal. There is much variation in the base of the skull and in the formation of the palate, so much that it has been used in separating the different groups of birds. The skull is fused in the adult, thus the separate bones are not distinquishable. Therefore, young forms must be studied to separate the skull elements.[51] Typical bird skulls that the project includes are Figures A, B, C, and D on page 82, and Figure C, page 84.

These skulls were prepared by removing as much of the meat as possible and then cooking until the remaining meat could easily be removed. The bones were soaked in a weak solution of hydrogen peroxide to bleach them before they were glued back together.

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[51]Leverett A. Adams, op. cit., p. 87.

MAMMALIAN SKULLS

In mammals, the skull differs from that of many other vertebrates by having a large brain case, double condyles, heterdont dentition with teeth only on the premaxillae, maxillae and mandibles. The sphenoids tend to combine and form one element. The brain case is completely enclosed with the ethmoids, forming a cribiform plate at the anterior end, for the twigs from the olfactory tract. The jugal is extremely important as a brace for the maxillae, especially in forms with great stress on the molars, as in carnivores. The palatines, together with the maxillae, form a secondary shelf, the hard palate, ventral to the old mouth roof.

Although the skulls of all mammals show a general similarity, some striking differences separate the monotremes, marsupials, and placential mammals. The roof of the mammalian skull is left fairly intact with only a few small openings through which twigs of nerves and blood vessels pass, but the sides and the floor are pierced by numerous openings, through which the cranial nerves and blood vessels may either enter or escape from the skull. Although a number of forammine and openings are found on the lateral side, it is on the ventral face that most of them appear. Cranial foramina are for the most part surprisingly uniform in the class, mammalia.[52]

Typical mammalian skulls that the project includes are Figures A, B, and D, page 86, and Figures A, B, C, and D, page 86.

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[52] Leverett A. Adams, op. cit., pp. 87-94.

References:

Adams, Leverett Allen, An Introduction to the Vertebrates. John Wiley and Sons, Inc., New York, New York.

Glass, Bryan P., A Key to the Skulls of North American Mammals. Burgess Publishing Company, Minneapolis, Minnesota.

BIRD STUDY UNIT

Each spring we do a detailed study of native birds on field trips and in our classroom. The students appear to enjoy it and learn a great many new birds. At the beginning of the unit, I post twenty pictures of common birds and give a short daily quiz on how many each student can name. Of course most of them know such birds as an English sparrow, a starling, a robin, a screech owl, a cardinal, a blue jay, and a common pigeon. Many do not know the brown headed cowbird, slate-colored junco, the brown thrasher, a catbird, a mockingbird, a bluebird, the ruby-throated hummingbird, or a meadowlark. They always appear to be astonished wheh they find there are many different kinds of birds in our area whose names they do not know. The last few years, whenever a student sees a bird, he is to complete a bird sheet -- sample on page 91 -- for his bird notebook. This bird sheet has classification information of the common name, the scientific name and family name. There are spaces for quick check references. Field observation includes date, if observed in typical habitat, where seen, and choice habitat. There is a space for the song call notes as well as with what other birds it might be confused. Associates found in the same habitat are listed. Size and contour comparison as well as color blues for the male, female and juvenal are given as aids to identification. Migratory data includes the bird zone, whether it is a migrant or permanent resident, date of spring and fall appearance, where it winters, and its range. The location of the nest is given, along with materials for the framework and lining. Egg information includes the number in the nest, size, color and number of broods per season. There is a space for the egg to be sketched and colored. Feeding habits are included and how it obtains the food completes the sheet. The form for this plate was received from Doctor Gilbert W. Mouser, Michigan State University, East Lansing, Michigan, and adapted for high school use. The forms are printed by the local printing company. Each student is given a sufficient number for his notebook.

The notebooks are graded at the end of a six-week or eight-week period on completeness and number of birds seen. A few books will contain between thirty and forty sheets, while most of them will have between sixty and eighty sheets. We plan to do this again this fall and see if more birds will be seen in the fall than in the spring. Samples of the notebooks may be seen on page 88, Figures A, B, and C. Figure D is a chart of the birds one of the students saw in the latter part of March and April. The class also studied bird songs and calls from records that were purchased from the Laboratory of Ornithology, Cornell University, Ithaca, New York.

For bird conservation, we have reports on a few extinct birds, state game birds and hunting laws, federal laws concerning birds, and conservation and migration.

This year we marked migration routes for a few birds on a globe with lengths of colored thread and drops of paraffin to hold them in place.[53]

References:

Eifert, Virginia S., Invitation to Birds. Illinois State Museum, Springfield, Illinois.

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[53] Helen W. Boyd, op. cit., p. 72.

Eifert, Virginia S., Birds in Your Backyard. Illinois State Museum, Springfield, Illinois.

Forbush, Edward Howe, and John Richard May, A Natural History of American Birds of Eastern and Central North America. Houghton Mifflin Company, Boston, Massachusetts.

Hausman, Leon A., The Book of Songbirds. Grosset and Dunlap Publishers, New York, New York.

Lincoln, Frederick G., Migration of Birds. Doubleday and Company, Inc, Garden City, New York.

Mathews, F. Schuyler, Fieldbook of Wild Birds and Their Music. G. P. Putnam's Sons, New York, New York.

Pearson, T. Gilbert, Birds of America. Garden City Books, Garden City, New York.

Peterson, Roger T., A Field Guide to the Birds. Houghton Mifflin Company, Boston, Massachusetts.

Peterson, Roger T., How to Know the Birds. The New American Library of World Literature, Inc., New York, New York.

Wallace, George J., An Introduction to Ornithology. The MacMillan Company, New York, New York.

Zim, Herbert S., and Ira N. Gabrielson, Birds. Simon and Schuster, New York, New York.

NAMES

Page................

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Common

....
Family

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Scientific

QUICK CHECK

References

ok	Page Desc.	Plate
s of America	....	....
hews-Field Book	....	....
nders-Guide	....	....
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ield Observation

e ....

erved in typical habitat Yes No

re Seen

ice Habitat

ong Call Notes

ht be confused with

Associates

w list other birds often seen in itat described.

Aids To Identification

Size and Contour Comparison

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Actual Size in Inches

Color Clues

Male

Female

Juvenal

Migratory Data

Data collected in vicinity of

....
City State

Is Bird Zonal Yes No ....
Zone

Bird usually seen in vicinity as

Migrant ( ) or Permanent Resident ( )

Spring Appearance ....

Fall Appearance ....

Winters ....

Nest

Location

Materials

Frame Work

Lining

Eggs

Number in nest ....

Sketch Actual Size

Feeding Habits

Food

Obtained

BIRDHOUSES

There are nearly always some boys and a few girls who are interested in building birdhouses. Of course there are many different plans for the various kinds of houses. Figure A, page 93, is a wren house that is made from pattern number eleven, Build It Yourself Slatted Roof Wren House, Easi-Bild Pattern Company, Pleasantville, New York (Price: $.25).

Plans for the robin houses, Figures B and C, page 93, are located in Vance, Barker, and Miller's Biology Activities, J. B. Lippincott Company, Chicago, Illinois, 1954, page 239.

Plans for the purple martin house found in Figure D, page 93, can be located in Popular Science--Do It Yourself Encyclopedia, Volume I, pages 225-228. These each have detailed directions to build the homes, along with the correct dimensions.

References:

Denckla, C. Paul, "Building Your Nest Boxes to Last Longer," Audubon Magazine, Volume 59, number 5, September-November, 1957, pages 228,282.

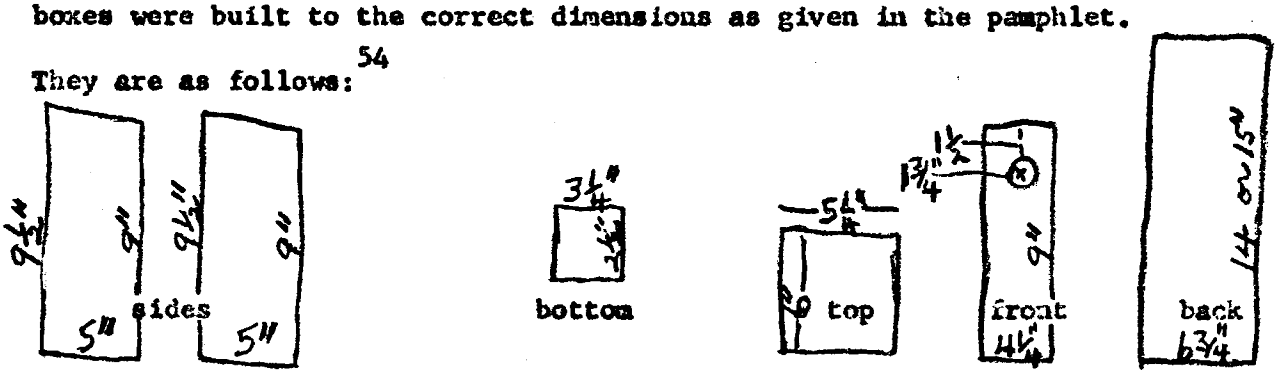
Martin House, Easi-bild Build It Yourself Pattern Number 69, The Easi-Bild Pattern Company, Inc, Pleasantville, New York, 1946 (Price $.50).

Peterson, Roger T., Bird Houses. National Audubon Society, 1000 Fifth Avenue, New York 28, New York.

Swiss Bluebird House, Easi-Bild Build It Yourself Pattern Number 110, op. cit., 1950.(Price: $.35).

BLUEBIRD LANE

Several years ago, a copy of Bird Houses by Roger T. Peterson arrived. Upon reading it, one sentence intrigued me. It says, "Everybody builds boxes for wrens, why not help the bluebirds?" The statistics were then given to prove that from a conservation viewpoint, the increasing of a diminishing species, it is more important to build boxes for bluebirds than for any other box-inhabiting bird. 'The decrease of this species has been very marked in some localities-as much as 80 percent-caused, it seems, by the competition of the starling and English sparrow.' That fired my imagination so I read the pamphlet and discussed the situation with the students. Several could not recall ever seeing a bluebird, so a project of building bluebird's houses was decided. Each student was to build three houses--two to put up near his home or in an area chosen by him and one to be given to the biology department to put up in a conservation area. The conservation area is on another teacher's farm, and he had just planted multiflora roses along his fence. The boxes were erected from three to four feet above the ground and preferably nailed to a solid fence post, facing the south or southeast. All the boxes were built to the correct dimensions as given in the pamphlet. They are as follows:[54]



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[54]Roger T. Peterson, Bird Houses (New York: National Audubon Society, 1948), pp. 1-12.

The completed box appears as Figure A, page 95. The tops were all removable for easy access to the box for checking as well as removing the old nests. Part of the grade was based on most natural color of painting and best placement.

During the last four years, the classes have greatly enjoyed checking the boxes and studying bluebirds. Each year some more bluebird houses are placed in different parts of the community. There are more bluebirds present in the area, and it appears that we are doing a little for bird conservation. The multiflora roses have grown and part of the boxes are well hidden by them. Parts of bluebird lane can be seen in Figures B and C, page 95.

Reference:

Peterson, Roger T., Bird Houses. National Audubon Society, New York, New York.

BIRD NESTS

Another project could be collecting birds' nests and identifying them. This is to be done only in the fall. Different birds use different materials in the construction of their nests and this, along with various methods of construction and location, serves as an aid to bird nest identification. For example, a chipping sparrow, see Figure A, page 98, builds it's nest in bushes, hedges, and in cedar trees, usually close to houses. The nest is a delicate, open work structure of fine, curly rootlets, cleverly interwoven and always thickly lined with horse-hair. Sometimes the nest is almost entirely constructed of horsehair.[55]

The red-winged blackbird's nest, see Figure A, page 98, has a mud base with coarse twigs and straw or sedge grass located in bushes or small trees. Our example was located in a multiflora rose hedge.[56]

An English sparrow's nest, see Figure A, page 98, is occasionally built in trees but usually in cornices, water sprouts, and similar places. It is made of grasses or any easily obtained materials, loosely put together, and lined with feathers.[57]

The starlings like to build their homes in tree cavities, eaves of houses, church steeples or any location that takes their fancy. The nest, see Figure A, page 98, is made of twigs, grasses, leaves, paper, or straw and lined with fine grass.[58]

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[55] T. Gilbert Pearson, Birds of America (Garden City, New York: Garden City Books, 1936), pp. iii, 41.

[56] Ibid., pp. ii, 248.

[57] Ibid., pp. ii, 17.

[58] Ibid., pp. ii, 236.

The robin's nest, see Figure B, page 98, is a thick, symmetrical bowl, made of mud reinforced with leaves and twigs, in which are frequently seen woven leaves, twine, paper, and rags. It is lined with soft grass and may be placed near the ground in any kind of tree. Occasionally robins build upon projections from a house, within or without barns, sheds, and other out buildings.[59]

A brown thrasher's nest, see Figure B, page 98, is a rather flat, loosely constructed structure composed of twigs, rootlets, leaves, hair, and some feathers. It is located in clusters of thorny vines close to the ground.[60]

A bluebird, see Figure B, page 98, likes appropriate boxes placed around the farm houses for its occupancy. The nest is composed of grass, weed stalks, a few bits of bark, and lined with finer grass blades.[61]

A phoebe, see Figure B, page 98, builds its nest beneath barn eaves, bridges, culverts, and on ledges. It is constructed of mud, grass, vegetable fibers, lined with some hair, grass and feathers, and nearly always decorated exteriorly with green moss.[62-63]

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[59] Ibid., pp. iii, 236.

[60] Ibid., pp. iii, 180.

[61] Ibid., pp. iii, 242.

[62] Ibid., pp. ii, 198.

[63] James H. Otto and Sam S. Blanc, Biology Investigations (Chicago, Illinois: Henry Holt and Company, 1956), p. 215.

RAISING RACCOONS

One of the projects that attracted the most attention this school year was the raising of some orphan raccoons. Of course it is necessary to have a permit to keep a wild animal in captivity, but the game warden was very understanding and issued the permit after learning the raccoons were orphans. They were distributed to three different students, who were to raise them to adulthood and then release them in a wooded area. Figure A, page 101, shows "Pepper" eating bread that had been soaked in milk. Figure B shows "Pepper" taking his bottle of milk at one of the feeding times.

TAXIDERMY

Every year some bright-eyed student wants to know if we are going to "stuff" some birds or animals or if he can begin this work immediately on a prize fish or shooting trophy. Taxidermy in these modern times, with borax mothproofing, can be a safe and fascinating hobby as well as filling many spare hours with undreamed of satisfaction. This past school year, six different students were very interested in taxidermy work and some of them are continuing to work with it.

In preparing and mounting a small mammal, a tough-skinned fox squirrel (Figure B, page 103) furnishes an ideal subject. An old squirrel has a skin of Herculean strength that makes a satisfying den trophy. When a taxidermist has succeeded in making a squirrel recognizable, he can sit back and congratulate himself, as there are more stuffed squirrels that defy identification than can be counted. Detailed instructions on how to make a squirrel presentable may be found in Pray's Taxidermy on pages 73-82.

Directions for the proper mounting of a bird (Figures A, C, and D, page 103) may be found in Pray's Taxidermy on pages 43-60.

Reference:

Pray, Leon L., Taxidermy. The MacMillan Company, New York, New York.

THE EMBEDDING OF SPECIMENS IN PLASTIC

The product called Bio-Plastic was used for the embedding of specimens in plastic. Bio-Plastic is a synthetic resin, furnished in the form of a syrupy liquid. With the addition of a catalystand the application of heat, Bio-Plastic hardens into a crystal clear solid. It is both versatile and convenient to use. It is a cold-pouring plastic and does not require high degrees of heat or pressure for its use. You do not need any special expensive equipment or any machinery for its use.

Molds may be purchased from Ward's Natural Science Establishment, Inc., P. O. Box 1712, Rochester 3, New York, or they can be made from glass cut to desired lengths and fitted together with scotch tape. Cooking tins, glass dishes, jars, and tin cans can also be used. The best results were obtained from the purchased molds and those made from glass. Mold release compound may be used to help get the blocks out easier later. However, sometimes it appears to mix with the Bio-Plastic and you do not get a crystal clear block.

There are four basic embedding schedules. The first is the dry opaque specimen for dried insects, starfish, sea horses, shells, minerals, and fossil specimens, coins and medals. The steps are

a. Prepare the supporting layer.
b. Wash specimen in ether or carbon tetrachloride to remove grease. Dry the specimen on a blotter.
c. Specimens having fissures or cracks should be placed in catalyzed plastic and put in a vacuum. If no vacuum is available, soak in uncatalyzed plastic for several days. Allow the excess uncatalyzed plastic to run off before embedding.

d. Pour the second layer; insert and orient the specimen.
e. Allow the second layer to gel.
f. Pour the third layer after the second layer has polymerized and allow plastic to gel. Cover top surface of plastic before final curing, to prevent tackiness.
g. Apply final curing.
h. Trim block as desired, sand and polish.[64]

The above steps were used for embedding the insects that are Figures A through L on pages 105, 106 and 107. The wet opague method for formalin specimens was used on the animals on pages 109 and 111, Figures M through T. The wet opague method is employed with biological specimens such as gross sections of formalin-preserved animals or organs, or for entire organs and small animals where a clear presentation of external form is particularly desired. The steps of this procedure are as follows:

a. Remove excess formalin (formaldehyde solution) from the surface of the specimen by blotting.
b. Air dry to remove free surface moisture.
c. Embed by following directions for dry opaque specimens, above, omitting step b (washing the specimen).

Wet opaque specimens - glycerine method.
In the great majority of cases, this is the technique to use with biological specimens. It gives the most generally satisfactory results and the most natural appearance of the specimens. Soft-bodied invertebrates and all insects should always be prepared by this method. The glycerine method can be used to great advantage where one does not wish to have the specimen "cleared" (rendered largely transparent). Almost any specimen that is dehydrated in alcohol (any fleshy specimen) and put into uncatalyzed Bio-Plastic will clear. This is not the case when glycerine is used. (If a "cleared" specimen is desired, use Method 4, next page). The glycerine method is the most nearly universal one for biological material, and the one biologists will most frequently employ.

(NOTE: Fresh specimens cannot be embedded in Bio-Plastic. All biological material must be fixed in 5% - 10% formaldehyde solution or some other fixative before embedding.)

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[64] How to Embed in Ward's Bio-Plastic. Wards Natural Science Establishment, Inc., P. O. Box 1712, Rochester 3, New York, pp. 1-4.

Adapt the graded mixtures of glycerine mentioned previously to the preserving solution used on the specimen; where 70% alcohol was used as a preservative, dilute the glycerine with 70% alcohol, and if formalin was used, dilute the glycerine with distilled water to obtain the concentrations of glycerine specified.

The steps of the procedure follow.

a. Transfer specimens directly from the perserving fluid to 10% glycerine for 24 hours. Then to 25%, 50%, 75% and 100% glycerine, leaving for 24 hours in each successive concentration.

b. Transfer specimen from 100% glycerine to 100% (anhydrous ethyl) alcohol, and leave the specimen in the alcohol until streamers of glycerine have stopped coming from the specimen. (In most cases, 98% isoprophyl alcohol may be substituted.)

c. Dry the specimen in the air.

d. Transfer to uncatalyzed plastic. Make several changes. (Plastic will become cloudy as the remaining excess glycerine comes to the surface.)

e. Mount as in the Dry Opaque Method, omitting step b (washing the specimen).

4. Cleared Specimens

For specimens where internal structure is to be studied, as in embryos:

a. Wash out the preserving fluid with water. In most cases 8 to 24 hours in running water is sufficient. For very large specimens a longer washing period should be used, while for smaller specimens less time may suffice.

b. Dehydrate through an ascending series of alcohol to 100% alcohol. The more delicate the specimen, the closer the stages of alcohol should be to prevent shrinkage and collapse of the specimen.

c. Place the specimen in uncatalyzed plastic until the specimen becomes transparent. If specimens are very delicate, go through an ascending series of plastic with styrene - 25%, 50%, 75%, and 100% plastic.

d. Mount as for Dry Opaque Specimens, omitting step b (washing the specimen) and c (soaking in plastic).

SPECIAL NOTES: A good text on microtechnique should be consulted on the staining and clearing of specimens. The preparation of the specimen may be much the same as that employed in preparing material for mounting on microscope slides.[65]

[65] *Ibid.*

CHAPTER III

ADDITIONAL PROJECTS

It is necessary to have a great variety of project ideas available for the students. The teacher should not be dictatorial, but let each student modify or adapt the idea to his own idea within reason. Perhaps the student can find a better method of doing the same thing by changing the project procedure. One must have projects that appeal to students with a wide range of ability and intelligence. These lists that have been compiled have something for the superior student as well as the student with low ability and low achievement records.

These additional project ideas have been divided under the headings of botany, conservation, miscellaneous and zoology.

The botany group includes those for the Thallophytes, Bryophytes, Pteriddphytes, and Spermatophytes.

Conservation of our natural resources (including plants, animals, trees, soil, water and minerals) is receiving much attention and publicity. As it vitally affects all people, everyone should be very interested in proper conservation. These lists of projects help to teach conservation as well as give the student understanding.

The miscellaneous group includes those projects that may be either botany or zoology, or both. It also includes health and first aid.

The zoology section is a group of projects that deal with animals, including humans. There is a great variety and something for anyone's interest.

These lists have been compiled from many sources such as: _The American Biology Teacher_, _Turtox News_, laboratory manuals, textbooks, Helen W. Boyd's book, and National Science Teachers Association publications.

The first list is botany projects, followed by conservation, miscellaneous and zoology projects.

BOTANY PROJECTS

1. Raise cultures of bacteria.
2. Raise cultures of molds and examine.
3. Culture and examination of yeast.
4. Collect mushrooms, bracket fungi, rusts, smuts, lichens, and algae. Identify and study.
5. Make a poster on penicillin, showing its appearance as penicillin mold, the process of making it into medicine, etc.
6. Collect different types of mushrooms. Distinguish between the poisonous and non-poisonous ones.
7. Modeling clay models of the types of bacteria.
8. Grow a pure culture of bacteria from a mixed culture.
9. Make charts of: (a) types of algae, (b) reduction of Spirogyra, (c) algae used for food, (d) types of molds, (e) life history of wheat rust.
10. Show the effect of yeast in breadbaking. Use both dry and compressed yeast.
11. Do spore printing.
12. Make fungus lapel ornaments.
13. Examine nitrogen-fixing bacteria.
14. Seasonal growth of algae.
15. Prepare bacteria smears.
16. Study the distribution of bacteria.
17. Gather and make a mushroom collection.
18. Collect and identify various molds.
19. Husbandry of molds.
20. Collect, identify and mount moss specimens.
21. Collect, identify and mount fern specimens.
22. Make enlarged drawings of: (a) life cycle of moss, (b) life cycle of ferns.

23. Collect and germinate fern and moss spores.

24. Collect and identify a group of mosses and liverworts.

25. Germinate fern prothalli.

26. Make a collection of dried seaweeds.

27. Make an exhibit on diatomaceous earth and its uses.

28. Make an exhibit on the fungi used in making antibiotics.

29. Make a study of an "air fern."

30. Prepare a life cycle of a pine tree (or other cone-bearer) and mount.

31. Make a wood collection of twenty trees.

32. Collect ten or more common garden flowers and identify them as monocots or dicots and as annuals, biennials, and perennials.

33. Make a chart comparing a green leaf to a factory.

34. Make a chart to show a comparison of photosynthesis and respiration.

35. Make a chart showing the comparison of a monocot and a dicot seed.

36. Make a large drawing to show structure of the following: (a) a typical root, longitudinal and cross section; (b) internal structure of a leaf, (c) comparison of a monocot and a dicot stem.

37. Make an exhibit of four different kinds of roots.

38. Extract chlorophyll from a leaf by heating it in alcohol. Test leaf for starch.

39. Set up an osmosis experiment and explain it to the class.

40. Collect twenty different kinds of flowers or leaves; mount either in book or on poster and identify.

41. Make a collection of leaves to show differences in venation, shape, margins, tips, bases, simple or compound. Mount and label correctly.

42. Collect pollen from five or more different types of flowers or trees. Examine under a microscope and sketch appearance.

43. Make a plaster of Paris model of a cross section of a leaf or seed.

44. Plant fifteen or twenty bean and corn seeds. As they sprout, pull them up, press them, and mount on a large bristol board or corrugated board. Draw a ground line to show the difference in sprouting.

45. Make either colored drawings or dimensional posters of a typical flower, seed, stem, or root.

46. Make a modeling clay or art paper model of a typical flower.

47. Germinate seeds and find germination percentage for a particular variety.

48. Do experiment to show seed pressure.

49. In February, show forced flowering by using pussy willow, staminate willow tree branches, Forsythia, cherry branches, and horse chestnut branches.

50. Collect, mount and label correctly leaves, bark samples, flowers, pollen, fruit and seeds from five or more deciduous trees.

51. Make a chemical garden and grow plants such as tomatoes without soil.

52. Make weeds and wild flowers collections. Choice of techniques include: (a) spatter print, (b) photographic print, (c) carbon print, (d) plaster of Paris mounts or molds.

53. Make a model of plant cell.

54. Make photomicrographs of various cell types.

55. Show on a map or chart plant formations of the United States. For example: desert plants in the desert, forests in the mountain ranges, etc.

56. Prepare a classification key for common trees or wild flowers.

57. Make a collection of roots.

58. Make a study of responses of roots to different tropisms and stimuli.

59. Do a study of the effects of Vitamin B_1 on plant growth.

60. Make a collection of winter twigs.

61. Do budding and grafting - cleft grafting, whip grafting, and budding.

62. Tree survey of city streets.

63. Making leaf prints.

64. Extractions of leaf pigments.

65. Effects of light on growing plants.

66. Variations in flower pollen.

67. Testing seed variability.

68. Make a collection of different types of climbing stems.

69. Make a mounted display of fruits and seeds.

70. Take photographs of various kinds of trees, and mount them on a display board.

71. Make plaster casts of tree leaves.

72. Extraction of plant enzymes.

73. What makes popcorn pop--the hypothesis was "When enough heat is added to popcorn to change the moisture inside to steam, the steam exerts sufficient pressure to explode the corn." Sixty grains of corn are to be used. Twenty are normal, twenty have the embryo cut out, and twenty have the hull cut off except over the embryo.

74. Grow and study carrot tumors.

75. Take eighty steps from a given point. Do a detailed study of plants found on or near the line. It may also be done by taking twenty steps in each of the four directions and doing a detailed study of the plants found inside the square.

76. Collect and mount seed and fruit dispersal types.

77. Do a study of dry land plant successions.

78. Do plant hormone experiments.

79. Do plant experiments with Gibberellic acid.

80. Make leaf clearings.

81. Photoperiodism studies with plants.

82. Absorption and translocation of water in plants.

83. Do leaf preservation of autumn leaves for the Thanksgiving and Christmas tables.

CONSERVATION PROJECTS

1. Make oral or written reports or exhibits on one or more of the following:

   a. the oxygen-carbon dioxide cycle of plants and animals.
   b. the chain of life in a pond.
   c. the effects of the draining of swamps on wild life.
   d. the effect of D.D.T. sprays on useful insects and birds.
   e. farming the ocean.
   f. my observation of an ant colony.
   g. aphids, the ant's milk cow.
   h. harmful insects in my garden.
   i. game and wild life refuges in my state.
   j. national forests.
   k. my favorite fishing spot.
   l. Illinois hunting and trapping laws.
   m. my visit to a fish hatchery.
   n. my visit to a quail hatchery.

2. A model made from soil to show slope with contour plowing, terracing, and strip farming. Use colored art paper or small printed sticks to represent crops.

3. Make a desert terrarium.

4. Grow plants in a chemical solution without soil.

5. Construction of a soil profile.

6. Capillary movement of water in soils.

7. Models of soil conservation practices.

8. Factors in the rate of evaporation.

9. Sediment content of streams.

10. A school tree nursery.

11. Study of stream pollution.

12. Wildlife destruction on roads and highways.

13. Photograph and prepare a display of soil conservation methods in your community.

14. Make a model of a dam with a fish ladder.

15. Photograph and prepare a display on poor conservation practices in your community.

16. Make a map showing wildlife preserves, refuges, parks, etc., in your state.

17. Prepare a chart of the types of wildlife that need protection in your community.

18. Experiment on the effects of sudden changes in temperature on rocks of various types.

19. Prepare a rainfall map of the United States.

20. Prepare a group of wildlife foods which man may eat.

MISCELLANEOUS PROJECTS

1. Plaster of Paris models of plant and animal structures.

2. The construction and maintenance of scrapbooks on selected biological topics may prove useful. Examples are: "Photosynthesis--Green Magic," "The Conquest of Polio," "Your Heart," "Water Resources of Illinois," "Game Animals of Illinois," and "Cancer."

3. Make a miniature sand dune area with life zones arranged on the proper order. Such an area should be made after observing and studying life zones.

4. Any drawings may be done in other media: soap carved, clay modeled, jig-sawed, paper mache, or balsa wood. These make a fine collection of student-made models.

5. Make any of the following: (a) balanced aquarium, (b) semi-aquatic terrarium, (c) woodland terrarium, (d) tropical aquarium, (e) ant nest, (f) mosquito hatchery, (g) house-fly hatchery, (h) reptile cage, (i) hamster cage, (j) insect cage, (k) a salt water aquarium.

6. Make microscope slides.

7. Prepare an exhibit of the chemicals found in living things.

8. Do a comparison of two environments.

9. Construction of habitats (include a woodland, desert terrarium, bog terrarium, and a tropical habitat).

10. Plant and animal phylum trees.

11. Take a series of photographs of different types of environments in your local area (woodland, field, swamps, ponds, etc.).

12. Make a map of your community showing the various types of habitats found there.

13. Separating the various tars in tobacco.

14. Make a demonstration of tests to determine color-blindness.

15. Make a detailed analysis of your family's diet.

16. Test common remedies.

17. Investigate leading causes of death.

18. Comparison of advertising of common remedies with the statements on the actual package of the remedy.

19. Display poster of the various agents that cause diseases.

20. Study of quarantined diseases in your community in 1930 and today. Analysis of the reasons for any changes.

21. Prepare display charts of plant and animal breeding experiments.

22. Do a nutrition experiment with bacteria.

23. Two starch digestion experiments using agar plates.

24. Learning to live with radiation experiments and tests.

25. Demonstration of antagonism and synergism of biologically active chemicals.

26. Tests of reactions of roots and stems to change in position.

27. Participative visual aids.

28. A changeable electric bulletin board.

29. The use of liquid rubber in making plaster models for science classes.

30. A project to vitalize biology with live animals.

ZOOLOGY PROJECTS

1. Do nutrition experiments with white rats.

2. Make a microcosm.

3. Make models (using plaster of Paris or modeling clay) of:
   a. Amoeba
   b. Paramecium
   c. Hydra
   d. Coral, and
   e. Jellyfish.

4. Make posters of:
   a. classification of the Protozoa
   b. comparison of the Amoeba and Paramecium
   c. drawings of five to ten typical Protozoans
   d. reproduction in the Obelia
   e. drawings to show three different kinds of coral reefs
   f. life cycle of the malarial fever parasite in the mosquito and man.

5. Collect pond or lake water for microscopic study (both compound and simple). Then make drawings and write descriptions.

6. Watch regeneration in a flatworm such as Planaria.

7. Make posters to show:
   a. life history of sheep liver fluke
   b. life history of tapeworm
   c. life history of the hookworm, showing how it enters the human body
   d. internal structure of the earthworm
   e. internal structure of the oyster or clam.

8. Make a collection of insects--this may be of one order or of the entire class.

9. Make a collection of Crustacea; preserve and label correctly.

10. Make a collection of helpful insects.

11. Make a collection of harmful insects.

12. Make charts or posters on:
    a. classes of Arthropods
    b. structure of a grasshopper
    c. protective coloration in insects
    d. comparison of a moth and a butterfly
    e. complete metamorphosis of an insect
    f. life cycle of Japanese beetle.

13. Write papers or make illustrated booklets on:
    a. harmful insects
    b. helpful insects
    c. the honeybee
    d. the housefly
    e. control of insect pests
    f. malaria
    g. yellow fever
    h. Texas tick fever
    i. protective coloration.

14. Have an observation bee hive.

15. Make written or oral reports on one of the following:
    a. make an observation of some animal such as a fish or a frog in an aquarium, a turtle, a caged bird, rabbit, or some other. Observe how it breathes, eats and moves about. Draw a sketch and label all parts.
    b. make a collection of snake stories and tell them to the class
    c. select one of the orders of mammals and look up additional information and write a report on it
    d. beneficial birds of my community
    e. harmful birds of my community
    f. snake farms
    g. alligator farms
    h. frog farms
    i. strange mammals of the world
    j. migration of birds or fish
    k. conservation of fish or birds or fur-bearing animals
    l. animal communities.

16. Make charts or posters on the following:
    a. wild animal tracks
    b. an identification chart of ten birds of your community, including the name, a sketch or picture, food, nesting habits, number and appearance of eggs, whether permanent resident or migrant, habitat (wooded area, open field, swamp, etc.) and economic importance
    c. a poster showing the orders of mammals, including a drawing or picture of a mammal, its identifying characteristics (make a sketch to show this), its natural habitat and its life zones.
    d. make a map showing life zones of mammals
    e. a series of charts showing migration of ten birds
    f. a chart showing the mammals native in your section. Give the name, order to which it belongs, habitat, diet, migrant or permanent resident, whether it hibernates and economic importance.
    g. collect or draw pictures of animals, both foreign and domestic, belonging to the five classes of vertebrates. Label each with the common name and scientific name.

17. Make a plaster cast of some animal tracks.

18. With several classmates, make an aquarium of native fish.

19. Mount a bird, chicken, or some small animal.

20. Dissect a chicken foot. Attach a cord to the tendons. See if you can control the movement of the toe and the entire foot.

21. Incubate chicken eggs. Make observations at the end of twenty-four hours, forty-eight hours, and every other day until the end of the indubation. Make microscopic slides of the first two observations and preserve the other specimens.

22. Prepare mounted skeletons of any fish, frog, snake, bird, or cat to show evolution of bones.

23. Preserved specimens showing the heart exposed so the students may see the transition of a single-one-chamber heart to a four-chambered heart.

24. Cultivate a single frog egg in test tubes.

25. Make a chart showing anologous bone structure in man and three other vertebrates.

26. Make a chart showing the development of the skeleton from the Amoeba to man.

27. Make a chart showing the different kinds of joints in the human body.

28. Make a chart showing the different kinds of muscles; locate these in the human body.

29. Start a booklet on service systems of the human body. Put in drawings of the skeleton, structure of the bones, kinds of joints, kinds of muscles, and their location in the human body. Plan to add additional chapters as each system is studied.

30. Prepare and mount a cross section and a longitudinal section of a bone.

31. Make a food substance chart. Use the following headings: substance, kind of substance (organic, inorganic, etc.), function, and source.

32. Make a vitamin chart, using the following headings: vitamin, best source, essential for, and deficiency symptoms.

33. Plan a balanced diet for yourself for one week. Consider factors such as age, sex, activity, size and body type when you plan this.

34. Make written reports on diseases affecting part of the digestive tract, such as: Jaundice, Gastric Ulcer, Dyspepsia, Appendicitis, Trench Mouth, Mumps, and Pyorrhea.

35. Make a summary chart of digestion using the following headings: place of digestion, glands, secretions, enzymes, food digested or work done.

36. Make a large poster showing the parts of the digestive tract.

37. Make a plaster of Paris model of a tooth.

38. Make a plaster of Paris model of a villus.

39. Make a large chart showing a villus and its parts.

40. Feed rats a protein deficiency diet.

41. Make menus, posters, and charts showing well-balanced meals and healthy individuals resulting from proper nutrition.

42. Prepare a blood slide for each member of the class.

43. Observe the circulation of blood in the tail of an anesthetized fish or web of a frog's foot.

44. Take pulse rate before and after exercise.

45. Do a study of a beef, sheep, or hog heart obtained from a local butcher.

46. Learn to type blood. Demonstrate to the class the correct procedure. The student may type the blood of their family and friends.

47. Make a wall chart showing a simplified drawing of the heart, its valves, and vessels. Show a section of an artery, vein, and capillary.

48. Prepare a series of reports on blood diseases such as leukemia, anemia, etc.

49. Make a spirometer and measure the lung capacity of several classmates.

50. Poster of lung structure.

51. Chart showing the development of the respiratory system from the amoeba to man.

52. Diagrammatic drawing of lung air cell showing how gases are exchanged between the air and alveoli.

53. Make a series of reports on diseases of the respiratory tract, respiration problems at high altitudes, artificial lungs, iron lungs, etc.

54. Make chart showing the excretory system of humans.

55. Do examinations and make drawings of a fresh animal kidney, ureter, and bladder. (Obtain from a butcher).

56. Concentrate upon a student's problem of severe acne. Study their diet, bathing facilities, and use of hair oil. Outline a course of procedure for each person and check their condition frequently.

57. Make models of the eye and ear.

58. Report on "endocrine deficiency diseases."

59. Culture various bacteria in the laboratory and examine under the microscope.

60. Make a chart in which you list common diseases and then give the following information: how spread, incubation period, early symptoms, methods of prevention or treatment, how long it is communicable, how serious, and complications which may develop.

61. Make a poster to show the desirability of having Salk vaccine innoculations.

62. Experiment with alcohol on raw egg or animal tissue.

63. Make a collection of current event articles which relate to alcohol and alcoholism. Observe the court's cases that have to do with alcoholism.

64. Poster or chart comparing embryos of different vertebrate animals to show structural similarities.

65. Make a heredity chart of your own family tracing some special characteristics as eye color, curly hair, twins, etc.

66. Make models of cells with clay to show mitosis and meiosis. Use different colored clay for the chromosomes, cytoplasm, etc.

67. A project of crossing (begin in September) a brown mouse with a white one. By the time Spring arrives, the F_2 generation will be present for: (1) hybrid-hybrid cross, (2) hybrid brown back crop cross, (3) hybrid with white (also pure).

68. Differences in taste reactions are inherited. There is a specialty in treated paper to be used in the experiment which may be obtained from American Genetic Association, 1507 M. Street, N.W., Washington, D. C. Make a chart for the family of each student.

69. Molding in plastic. Mount insects and animal specimens in plastic.

70. Each student is asked to collect forty specific insects from ten different families.

71. Observe behavior patterns in albino mice.

72. Make an artificial iron lung from a fruit jar, rubber sheet, and a doll.

73. Trap small mammals.

74. Transfer malignant tumors in mice and study the heredity possibilities.

75. Bird banding.

76. Corrosion mounts--inject circulatory vessels of various organs, i.e., lungs, kidneys, etc., with Bio-Plastic and then rot off other tissue--mount in plastic.

77. Prepare a series of vertebrate skulls, learn key characteristics, dental formulae, major bones, foramen, etc.

78. Prepare study skins of small mammals.

79. Prepare bird skins, study mounts.

80. Make a comparative series of vertebrate brains, preserved in alcohol or in plastic.

81. Make a serial section of some small animal such as a Planaria.

82. Make a graded series of the embryonic stages of a frog.

83. Make a graded series of the embryonic stages of a chick.

84. Study the effects of insecticides on insects.

85. Collect bird's eggs, nests, etc.

86. Microphotography.

87. Embalm an animal for dissection, inject blood vessels and lymphatic system.

88. Try the Jaswant Singh Bhattacharji blood stain (a new, simple and rapid method).

89. Induce ovulation in a frog and attempt artificial stimulation of ova to cleave.

90. Make a model in clay of some organ or organism, fire or cast in plaster.

91. Prepare lantern slides, India ink on glass.

92. Make a working model of a heart with valves.

93. Disassemble, clean and adjust a microscope (with restrictions).

94. Mount various fish scales of different types; using the scale as a negative, make a photographic enlargement of it (Bioscope will work).

95. Make "duramount" microscope slides (use of Bio-Plastic instead of balsam).

96. Secure a foetal pig, cut into one-half inch slices, imbed in plastic.

97. Collect and display various types of coral.

98. Collect and display various types of sea shells.

99. Collect and display dried echinoderms.

100. Identify the invertebrates in one cubic foot of soil.

101. Make a display showing the internal structure of a bee hive or an ant colony.

102. Prepare an exhibit on the harm done by termites.

103. Prepare an exhibit on the various products obtained from insects.

104. Collect and display some types of dried sponges.

105. Do experiments to show gain and loss of water by a frog.

106. Prepare a "phylum tree" of the vertebrates.

107. Make a display showing the differences in skeletal structure between fishes, amphibians, reptiles, birds, and mammals.

108. Photograph native vertebrates in their habitats.

109. Experiments on effect of oxygen in blood.

110. Study of the human senses.

111. Conditioned reflexes in animals.

112. Perform experiments on vitamin deficiency diets with animals.

113. Crossing of fruit flies to study heredity.

114. Collect numerous insects of the same species. Tabulate variations of characteristics within the species.

115. Prepare display charts of the different varieties of breeds of domesticated animals.

116. Demonstrate living parasites of earthworms.

117. Observe feeding habits of grain insects.

118. The raising of laughing doves in the school laboratory.

119. Fishing for Nematodes from roots by the use of tap water.

120. Circulation of blood in goldfish.

121. Do a blood typing project of students in the class.

122. Do experiments with living damsel fly larvae as supplementary material for the study of insects.

123. Preparation of insect mounts.

124. An experiment to determine the uptake of iodine 131 by a test animal.

125. A study of artificial insemination.

CHAPTER IV

SUMMARY

The method of teaching by projects is widely accepted as a desirable procedure in education. It is especially useful in the sciences where many of the materials are of the so-called laboratory and field types. The project method offers the student the opportunity of learning by activity, seeing, doing, and handling. A project may include a series of related problems and may cover a small area of subject matter or a very large one. The problems are usually so begun that those attempted first suggest or even demand that more follow.

This method requires a high types of teaching in every respect. It is necessary that there be more detailed planning, more foresight, more knowledge, and also more skill on the part of the teacher. To the teachers of real ability who are well informed in their field of subject matter and love teaching there is no substitute for the method. Anything else is inadequate by comparison. Students, once trained in this method, are likely to be dissatisfied with any other. Such factors as the school's location, the number of students in a class, and the number of classes per day, may modify the course selected and the extent to which individual work may be pursued. However, any trend toward the method is likely to result in a distinct movement toward advancement in the teaching of the course.

This paper has tried to portray accurately the teaching of biology by the project method, give sample projects completed by students and list many other available projects. If one person is influenced by the paper to use the project method of teaching, the paper has served its purpose.

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